SCIENTIFIC MEMOIRS

BY

MEDICAL OFFICERS OF THE ARMY OF INDIA.

EDITED BY

W. R. RICE, Esq., M.D.,
SURGEON-GENERAL WITH THE GOVERNMENT OF INDIA.

PART VII.

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Some observations on the life-history of *Sclerostomum tetracanthum* Diesing, and on Sclerostomiasis in equine animals; in connection with a so-called outbreak of "Surra" at Shillong.

BY

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FOR some eighteen months past there has been present, among equine animals at Shillong, an epizootic, which has resulted in the loss of a large number of valuable animals.

Though by no means confined to them, this outbreak was especially severe among the transport mules attached to the regiment stationed there; and I understand that, from first to last, between sixty and seventy of these have either died or had to be destroyed.

When first the mortality became serious, a veterinary surgeon was sent to investigate the nature of the outbreak, and his diagnosis was, that the disease was "Surra." His recommendations consisted in the removal of the lines to a new site, and in various sanitary improvements, the adoption of which have undoubtedly gone far to diminish the severity of this epizootic. The disease cannot, however, be said to have been stamped out, as cases have continued to occur ever since; and it is these later cases that have come under my own observation, some six having been examined during the period of about five months that have elapsed since my attention was first directed to the matter. These latter cases, I am told, are in every way identical with those that appeared before them, and it is on this account that I have spoken of the cases as "Surra." As to what sort of cases are called by this name elsewhere I am unable to say, and whether the cases I am about to describe should be properly called "Surra" at all must remain entirely a matter of opinion. All that can be said is that the cases I have seen formed part of a continuous epizootic the earlier cases of which were diagnosed as "Surra" by competent veterinary authority, and that there can be no practical doubt that the earlier and later cases were of the same character. It is likely enough that a good many, quite distinct, communicable diseases may be included under this term, and, from the analogy of what we find in human medicine, it may be expected that nothing but confusion can arise should any one attempt to pin down a loose vernacular term such as "Surra" to some one definite pathological condition. The cases

I have personally examined were undoubtedly instances of helminthiasis, and, whatever may be called "Surra" elsewhere, that these animals died from the action of nematode parasites, and from no other cause, is a matter which admits of not the slightest doubt; and it is equally certain, whatever may be the correct vernacular name of the disease, that such cases are a source of very heavy mortality in Assam; and I have collected some information tending to show that the same is the case in Burma.

As will be seen in the sequel, the disease is one which can hardly spread to any great extent in a dry climate; but, as it is by no means unknown in Europe, a tropical temperature is by no means essential. Most of the animals I have examined were perfect museums of parasites; but, of the various species found, only two[1] can be considered as effective in producing the mortality, and these are two strongyloid mematodes, closely allied to each other and to the well known *Dochmius duodenalis* found in the human subject, which latter parasite has of late been causing a terrible mortality among human beings in Assam, and the life-history of which it has lately been my special business to investigate. These two parasites are *Sclerostomum tetracanthum* Diesing and *S. equinum* (Rudolphi), and, though the latter not unfrequently determines the sudden death of animals, it is more especially the former which is the efficient agent in the present epizootic, and it is its life-history only that it is proposed to discuss in the present paper. In it I have preferred to adhere to the generic name *Sclerostomum*, as the worm agrees in all its characters with the definition of the genus, and I can see no advantage in forcing it into the already unwieldy genus *Strongylus*.

The first case that was brought to my notice was that of an officer's charger, which was sent to me by Dr. Hall as a case of "Surra," and, knowing the interest I take in epidemic disease, he believed would interest me. I was at once struck with the extraordinary resemblance which the case presented to one of anchylostomiasis in the human subject. There was the same weakness and wasting, and the same characteristic deadly pallor of the mucous membranes; indeed, the similarity was so striking that I at once proceeded to examine the dung microscopically: nor was my astonishment diminished when I found that it contained countless numbers of ova, absolutely identical in general appearance with those of *Dochmius duodenalis*. A reference to the micrometer, indeed, showed them to be considerably larger than the ova of the latter; but, in all other points, the resemblance is so close that it would be quite impossible to distinguish them by any other test than measurement. Shortly after, the animal's recovery being obviously hopeless, its destruction was decided upon by a board of survey, and I obtained the opportunity I had been hoping

[1] I have since found that, under the name of *S. equinum*, I included two closely allied species, *S. equinum*, and another, which appears to be new to science, and which I describe in a note, following the present paper, under the name of *S. robustum*, sp. n. Hence three species were concerned in the mortality.

for of seeing the actual parasites which produced the eggs, and of whose exact nature I could only give a guess, as none of them could ever be found in the animal's dejecta. As a matter of convenience, the animal was destroyed, and the examination made, at the mule lines, as I could then have the assistance of the transport conductor, and of the salutri, who were necessarily more accustomed than I to dissecting such huge subjects. While walking to the spot with Mr. J. Brown, the transport conductor, I explained to him what I expected to find, and to my surprise he replied, "I know you will find exactly what you expect then, Sir, for I have found worms of the sort you mention, sometimes absolutely in buckets-full, in all the cases we have lost here, and we have had some 60 either died or destroyed; but I was only laughed at when I said I thought they were the cause of death:" and he added that it was in the stomach and large intestine that they would be found. On opening the animal's cœcum a most extraordinary sight presented itself. There was absolutely no exaggeration in the conductor's statement, for so enormous were the numbers of worms that the whole of the intestinal contents seemed nothing else than a writhing mass; and I believe that, could they have all been collected and cleaned, they would have more than filled an ordinary stable bucket. It will be best, however, to give a full account of this case, as it is typical of all the rest, and so will save the necessity of entering much into detail in the others. The animal had been ailing for some three months, the principal symptom being wasting. It was said to have had "fever" on several occasions, but the temperature had not been taken by the thermometer. It fed greedily as a rule; but the appetite was capricious, and occasionally it would be off its feed for days. The most prominent symptoms at the time it came under my observation have already been described: for the rest, its organs seemed healthy, the sounds of the lungs and heart presenting nothing peculiar. I examined the blood on three several occasions, and could find no trace of the so-called "Surra" parasites (*Trichomonas Evansi*) in the blood, though this does not imply their necessary absence throughout the case, as their presence is acknowledged to be intermittent. On opening the abdomen, the peritoneal cavity was first carefully examined, and found to be healthy, with the exception that three specimens of *Filaria papillosa* Rudolphi were discovered; but there was not the faintest sign of irritation about the situations where they were found. The cœcum was then opened, and the upper half of the large intestine were found to contain immense numbers of worms. Putting aside *Oxyuris curvula* Rudolphi, of which a few were present, they might be divided into two categories, although a close search would always show large numbers of intermediate size. The first or larger sort[1] were about three-fourths of an inch long, greyish red in colour, or with a distinct black streak throughout their length, owing to their being gorged with blood. The largest specimens (female) have a mucronate tail,

[1] Afterwards identified as a distinct species *S. robustum* sp. n.

while the males, which scarce exceed half an inch in length, have a large copulatory bursa. These larger specimens, of both sexes, were almost all adherent to the mucous membrane in exactly the same way as *Dochmius duodenalis* is found in the human duodenum, and so firm is the grip with which they attach themselves, that it was often not altogether easy to detach them without damaging them, and the mucous surface would be pulled out into a conical projection by the effort. The large amount of blood which they habitually abstract was shown by the frequency with which long tails of clotted blood would be found hanging from the anus of the worms, and by the numerous streaks of blood to be seen amongst the intestinal contents. Although very numerous, for many thousands must actually have been present, the number of these larger specimens was quite insignificant in comparison with that of the smaller specimens forming the second category. These latter, however, proved to be all sexually mature, and large numbers (at least a quarter of the whole number) were found actually *in copula*. The main difference was that they were rarely, if ever, found adherent to the mucous membrane, and that it was quite exceptional to find any evidence of their containing blood. Apparently the smaller ones do not indulge in the habit of blood-sucking, at any rate as regularly as the larger kind. These smaller worms were present in such enormous numbers that the term "buckets-full" is no exaggeration to apply to the quantity: it would be impossible to make an even approximate calculation of the actual numbers; but the figure could certainly not run to less than six digits. Alike large and small specimens were confined to that portion of the large intestines in which the contents are semifluid, and still undergoing digestion. In the lower parts of the bowel, their numbers steadily diminished, and in the rectum, where the dung was quite formed, not a single specimen could be found. On closer examination these parasites proved to be *Sclerostomum tetracanthum* Diesing.

The whole of the mucous mm brane was closely spotted with the marks of recent and old bites inflicted by the parasites, from 10—20 being counted on an average square inch. In addition to these lesions, the bowel, when held up to the light, was seen to be studded with opaque spots about the size of a lentil; and, on feeling these spots between the finger and thumb, a distinct sensation, as of an imbedded small shot, could be made out. Dissection of these spots under the simple microscope revealed the fact that each contained, coiled up within it, an encysted worm, the largest of which were about the size of the smallest of those found free in the intestines, and a closer examination brought to light a number of small undercut ulcers, from which encysted worms had evidently but recently escaped.

The small intestine was free from parasites; but the stomach contained immense numbers of the smaller parasites, and was dotted with cysts in exactly the same way as the cœcum. The mucous membrane presented appearances

closely resembling those found in human anchylostomiasis, only in an exaggerated manner. There were the same irregular, petechial markings, and the same leathery appearance along the greater curvature, the same dull, slaty blue tint from chronic inflammation. All the other organs were healthy, except the liver, which was dotted throughout its substance with small whitish tubercles. These are probably cestode tubercles; but I have not as yet had sufficient leisure to decide the point with certainty.

Now, in this case, there is absolutely nothing to account for the horse's condition except the presence of the parasites, and, when their immense numbers, and the serious nature of the lesions they cause are considered, it is difficult to understand how any one can consider the cause inadequate to the effect, especially when it is remembered how much more serious in degree the injuries produced are than those effected by *Dochmius* in the human subject, about the fatality of which few now entertain a doubt. There seems, however, a sort of hostility to recognising the pathological importance of entozoa, alike among the medical and veterinary professions, and most of us can remember the difficulty with which the perfectly obvious connection between anchylostomiasis and the pernicious anæmia which it causes gained general acceptance.

In the case of the particular parasite which we are now discussing, its fatal importance seems to have been generally overlooked in India; but in Europe its adequacy to cause widely-spread mischief has been clearly recognised, at any rate by such as are best fitted to judge of such a matter. Speaking of *Sclerostomum tetracanthum*, Cobbold says: "Second only in clinical importance" (to *S. equinum*) "is the little four-spined strongyle (*S. tetracanthus*). The sexes, often seen united, are nearly of equal size, the largest females reaching nearly three-fourths of an inch. They infest the cœcum and colon, and have been found in all varieties of the horse, ass, and mule. The worm occurs in immense numbers, and is a true bloodsucker. Its presence occasions severe colic and other violent symptoms, often proving fatal to the bearer. As already announced in connection with my account of the tape-worms of the horse, this little worm may produce a virulent epidemic (epizooty). In the sexually immature state the worm occupies the walls of the large intestine, where it gives rise to congestion, echymosis, inflammation, and the formation of pus deposits. The species is readily recognised by its bright red colour, by the four conical spines surrounding the mouth, by the two neck bristles, and by the long three-lobed hood of the male, the posterior, three-cleft ray having a rudimentary or fourth branch attached to its outer edge. In some specimens sent to me by Mr. Whitway, I found this supplementary process fully twice as long as Schneider has represented it * * * * * * *. As regards the course of development of this worm we have yet much to learn. Although the worm is a frequent cause of epizooty in this country, it appears to be but little known on the Continent * * * * * As already remarked, the evidence of the frequency and destructiveness of this little worm in England is overwhelming."

The facts recorded in this extract comprise, practically, all that is said about the development of the parasites; and it is the gap left between the deposition of the ova in the dung of the one host, and the entry of the young parasites into another that I have been able to fill up, and which forms the essential part of the present paper.

To return, however, to the clinical aspect of the disease. The second case was that of a transport mule, which was in a dying state at the time of the destruction of the horse. The animal was too weak to stand and lay helpless on its side, but was perfectly conscious and fed quite greedily when grass was given it by hand. The breathing was deep and laboured, but the breath sounds were normal (apnœa of bloodlessness). The mucous membranes were absolutely bloodless, but there was but little subcutaneous œdema; and there was no true paralysis, but only extreme weakness. Bed sores were commencing to form over the haunch bones; the temperature was 97·8° (sub-normal). No worms could be found in the dung, but it contained countless ova. The blood was twice examined, and no trichomonads could be found on either occasion.

The animal was practically at the point of death when shot, and, *post mortem*, the changes found were practically identical with those found in the first case, only in a more advanced condition; and just as the latter exhibited appearances corresponding to those found in moderately advanced anchylostomiasis, this case showed those corresponding to the last stages of that disease. That no œdema of the extremities was present is probably due to the fact that the mule had been several days lying constantly on its side, but dropsies of the internal organs were present in a marked degree, the lungs being œdematous, and the pericardium and peritoneum full of fluid. The animal harboured, moreover, an even greater variety of parasites than the first case. None were found in the stomach, but this organ presented all the characteristic appearances of the first case; so that it is certain that they had been present there during a previous stage of the case, a fact which makes it probable that the worms, after escaping from encystment in that organ, soon pass along the intestine to the large bowel. In addition to *S. tetracanthum*, which was present in enormous numbers, 53 being counted in a single ounce of the fluid contents of the cœcum, two good-sized worm aneurisms, containing immature *S. equinum*, were found on the larger branches of the mesenteric arteries, and a few mature specimens of the same worm were found free in the intestine; but I doubt if these had much to do with the fatal issue of the case. Besides these, whole handfuls of a small amphistome fluke (*Gastrodiscus Sonsinonis*, Cobbold) were found in the cœcum and colon, in which situation also a few specimens of a pentastome, near *P. tænioides*, were discovered; while the stomach contained a large number of bots, and the small intestine, several *Ascaris megalocephala* Cloquet.

In all, seven *post-mortem* examinations have been made, and in every one there

could not be the least doubt that the cause of illness was mainly the presence of *Sclerostomum tetracanthum*, though, no doubt, its ravages were assisted by other parasites, and especially by *S. equinum*. In addition to the parasites already enumerated, the last case examined harboured, in the stomach, large numbers of *Spiroptera microstoma* Rudolphi; but a separate account of the other cases would only involve useless repetition, and take up needless space. Before quitting the clinical side of the subject I may remark that, from what I have seen, I am inclined to think that the colicky pains described in Cobbold as symptomatic of the presence of *S. tetracanthum* did not form by any means a prominent symptom of the cases I have witnessed. In these, recurring feverish attacks, followed by profound anæmia, wasting and exhaustion, with, at the end, dropsical symptoms, formed the most prominent features of the clinical picture. I am inclined to think that, when colic occurs, it is due to the associated presence of *S. equinum*. It must be remembered that Cobbold's information on this point is second-hand. The pressure, however, of my legitimate work prevented my being able to bestow much time to the observation of still living animals, and also prevented my ascertaining, as I had intended to do, in how large a proportion of apparently healthy animals fewer or more of the parasites might be harboured. I have no doubt that a very large number of not only apparently, but of really, healthy animals do harbour a certain number of the worms; for, unlike *S. equinum*, where a very few may indirectly cause sudden death, the severity of a case must be directly proportional to the number present, and, up to a certain limit of number, it is probable that no symptoms would result from their presence.

Such, then, being the circumstances under which these parasites were met with, I will now proceed to describe their free, or Rhabditis stage, as far as I have been able to observe it. The term Rhabditis stage is used because it has come into general use to denote the intermediate free stage of certain alternately parasitic nematodes. As a matter of fact, in this particular instance, the term is rather a misnomer, as the free *S. tetracanthum* I am about to describe, correspond much better to Rudolphi's genus Liorhynchus than to Dujardin's Rhabditis.

When my first equine patient was brought to me, but before its destruction enabled me to identify the parasite, I started cultivations of the ova contained in the dung, working on the same lines as those which experimentation with *Dochmius* ova indicated as most likely to succeed. Several cultivations accordingly were started with the diluted dung spread over sand; others with the dung simply placed in a covered crystalising glass; and others with the dung spread over patches of garden soil enclosed within four planks. In all of these experiments the ova hatched out on the third day after deposition, the mean temperature of the air being a little below 70°F., and development proceeded to a certain extent in all; but in no instance did it proceed to the adult Rhabditis stage. Some condition, necessary to the welfare of the embryos, was clearly

wanting, and, for some time, I despaired of getting any further success. About nine days after the start, a chance seed spouted up within the cultivation in the open, and, on the young leaves, was found a Rhabditis much further developed than any that had been hitherto obtained, a fact which seemed to show that plants formed, as it were, the intermediate host of the parasite. About the same time I made the disagreeable discovery that one of my own horses was affected with the disease. For some time, in spite of liberal feed, he had been getting out of condition, and at last he became obviously ill and unfit for work, and an examination of his dung showed that he, too, harboured large numbers of the same parasite as that which had brought about the destruction of the officer's charger first seen. Now the stable sweepings were thrown on to a heap near the stable which the conservancy carts persistently avoided clearing away; and, as it was placed on a sloping piece of ground, the drainage from the heap ran down on to the grass below; so, following out the hint given by the stray seedling, I examined first the dung heap, and then the herbage near it. The dung heap, like my cultivations, swarmed with immature Rhabdites, and plenty of such were found also on the grass; but here, in addition, completely mature specimens of both sexes, and less mature ones of all grades were found; so that the whole question of the life-history of the parasite was solved, it being evident that, while earlier phases of development of the free stage take place in horse-dung, the Rhabdites can only attain maturity by crawling out of their original home on to grass or other forage plants. No one special species or class of plants appeared to be particularly affected by them, and they were found indifferently on grass, and upon leguminous, and other dicotyledinous weeds, that flourished near the heap, the greatest numbers being naturally found close to it, though a few could be discovered, as much as 15 feet from the centre of infection.

Thus, wherever dung is dropped by an infected animal, an area of herbage, varying in extent with the slope of the ground and the amount of rainfall, will become so infested with rhabditic sclerostomes in various stages that the infection of any equine animal feeding on the grass is perfectly inevitable, and as the Rhabdites appear to be capable of continuous reproduction and multiplication, there is obviously, in damp climates, no possible limit to the period during which any given area may remain in a dangerously infective condition; for, as far as I can make out, all the conditions for repeated generations are found on forage plants, once the embryos hatched out from the parasitic eggs have escaped from the dung of their birthplace.

Having thus traced out briefly the various steps in the investigation, I will now enter upon the description of the free, or Rhabdites, stage of this very destructive little nematode.

The number of eggs produced by the entozoic worms is enormous, and, coupled with the immense numbers of worms often present, renders the diagnosis

of the disease by microscopical examination of the dung so easy a matter that an inspection of even the most cursory character usually suffices. The ova when deposited measure $\frac{1}{231}''$—$\frac{1}{250}''$ (about 0·11 mm.) long by $\frac{1}{480}''$ — $\frac{1}{500}''$ (about 0·05 mm.) wide, being thus rather narrower in proportion to their length than those of *Dochmius duodenalis*, to which, as already remarked, they present a strong resemblance in all other points. They present too, in perhaps an even more marked degree, the flattening of their longer sides, and exhibit a more or less segmented yelk, surmounted by a perfectly clear space, which is wider at the poles than elsewhere, the shell being as perfectly clear and transparent as the zone of fluid within it, and exhibiting microscopically a marked double contour. In freshly deposited dung, the ova will usually be found to be 4—12 segmented, but even earlier stages, and others in which the first indications of the outline of the embryo can already be made out may occasionally be found; but under no circumstances do they ever hatch out within the intestine. Doubtless, as Leichtenstern has experimentally demonstrated in the case of *Dochmius* ova, the cause of the ova not hatching out while still within the intestine is, that the presence of a free supply of oxygen is essential to the process, and the supply of this gas within the intestine is very limited. As might be expected from the general fragility of the envelope of the ova, they hatch out very shortly after deposition.

Experiments were made with cultivations of diluted dung spread over moist sand, with the slightly moistened dung set aside in a covered glass, with the dung suspended in water, and also with dung spread over a patch of garden soil enclosed within four planks. As far as concerns the hatching out of the eggs, it seems of little moment which plan be followed, though the experiments gave some reason for thinking that the more abundant the supply of moisture, the more rapid was the process, the eggs suspended in water hatching out, on the whole, more rapidly than those which were kept simply moistened; but, though the earlier stages of growth proceeded in water at perhaps an accelerated rate, they soon came to a standstill, and it soon became evident that water could not be considered a natural habitat for the Rhabdites. These points are illustrated by the following experiment:—

April 26.—Some dung from an affected animal, containing immense numbers of ova, diluted with water, and spread over a surface of clear sand in a crystallising glass.

April 27.—Ova further advanced in segmentation, but as yet no embryos. A portion of the surface of the cultivation set aside in a shallow tray of water.

April 28.—In the original cultivation there is but little change to be made out: on the other hand, in the material set aside in the tray of water, a few embryos have already hatched out, and most of the ova contain lively embryos.

April 29.—Ova in original cultivation hatching out. There are now large numbers of embryos in the tray of water, some of which have grown considerably, and are sufficiently advanced to admit of the genital area being made out.

April 30.—The embryos in the original cultivation are now about as advanced as those

observed yesterday in the tray of water, in which latter, however, no further advance has taken place.

May 3rd.—No change has taken place in either the sand cultivation or in the tray of water.

From this date no further development of the embryos took place, and, though many survived for a considerable time, their numbers steadily diminished, until, by the end of the month, no trace of nematode life could be discovered in even the original cultivation, all those that had been kept in water having died out within ten days of the commencement of the experiment.

In an experiment conducted with horse-dung simply damped, the development was even slower, ova still living, but unhatched, being observable as late as the eleventh day; while the ultimate fate of those that hatched out was the same as that attending the inhabitants of the first cultivation.

The experiment conducted in the open air, the dung being simply spread over an enclosed patch of garden soil, succeeded somewhat better, the embryos growing considerably, and their generative organs developing to such an extent as to occupy an even larger share of the body cavity than the intestinal canal. They, however, never reached the stage of sexual differentiation, and it was evident that some essential condition was wanting to enable them to complete their development. A hint as to the nature of this desideratum was, as I have said, first afforded by my finding, on the cotyledonary leaves of some chance seedlings that had sprung up within the little enclosure a Rhabditis which, though not yet mature, was further advanced than any I had yet seen.

It was about this time that I found that my own pony was affected. He had been getting out of condition for some time, and one day the syce reported that he had refused his food. On more closely examining the animal I found that he presented, in a less marked degree, the same symptoms as the horse I had already examined, and microscopical examination of the dung confirmed the diagnosis. I also found that near the stable a considerable dung heap existed, and I soon found that there was no need for any further artificial cultivations, as a very large one, under perfectly natural conditions, was now at my command.

In the actual dung heap I could find no specimens further advanced than those I had already reared; but, on examining the rank vegetation on and about it, I found abundant representatives of all stages up to maturity.

When first hatched out, the embryos are extremely transparent, and the details of their structure can only with difficulty be made out, the pharyngeal bulb being the only structure whose outline is at all distinct. They are provided with a long lash-like tail, quite half as long as the body proper, the lash tapering to such extreme tenuity that the highest powers are necessary to the resolution of its entire length, the body itself tapering off so gradually into the lash that it is hard to define their proportional length. Exclusive of this lash, they

measure about $\frac{1}{80}''$ (0 34 mm.) in length by rather less than $\frac{1}{1000}''$ (0·025 mm.) in diameter. Although I have frequently examined embryos just escaped from the egg, I could never make out any pulsatile action of the pharyngeal bulb, such as is seen in all the embryos of *Dochmius duodenalis*, but only irregular slow contractions of the pharynx. They grow with great rapidity, so that in a few hours they have attained a length of $\frac{1}{50}''$ (0·5 mm.), and have increased considerably in thickness. By this time the outlines of the internal organs have become distinct, the intestine being marked out as a distinct granular mass, between the lining cells of which the lumen of the tube pursues the serpentine course characteristic of young nematodes. A relatively large share of the body length is taken up by the pharynx and its bulb, a third of the body proper being so occupied, the pharynx being exceptionally wide and strong, and rather widening out at its aboral end than forming a distinct bulb. The portion of the body length occupied by the intestine proper is relatively short, only exceeding that of the pharyngeal portion by about $\frac{1}{800}''$ (0·034 mm.), the anus being placed rather far forward, so that the intestine does not extend into the long tapering tail. They change skin frequently, and any specimen containing many of them will be sure to exhibt a considerable number engaged in the process of getting rid of their old integuments, the long empty chitinous tube, still attached, giving rise to all sorts of queer appearances.

The development of the generative organs and of the lemniscus is exactly similar to that of *Dochmius duodenalis*; so that to enter into the details of the process would necessarily be merely a repetition of the description of the development of the Rhabditis of that parasite given in my recent "Report on the diseases known in Assam as Kala azar, and Beri beri;" and I will therefore proceed at once to the description of the mature Rhabditis, which presents such considerable differences from *Dochmius* that there would be no difficulty whatever in distinguishing the two species, even were they to be mixed together in a single tray. As far as I could make out, the emigration from their original home in horse-dung, on to plants generally takes place just before the distinction between the sexes first appears, that is to say, at a stage when the generative gland has already attained considerable dimensions, but at which the future sex cannot yet be determined.

The most distinguishing character of the Rhabdites, after their migration from the dung in which they were born on to forage plants, is the possession of a peculiar mouth armature, specially suited to subserve their needs in this new situation. This consists of a sharp, protrusible, chitinous style, which appears to be hollow, and to consist essentially of a prolongation of the pharynx. With this structure they are doubtless able to pierce the delicate cuticle of the plants that harbour them, and so to extract the nutritious juices contained in the cells beneath. The pharyngeal bulb, at no stage very distinct, is reduced to a mere widening and thickening of the posterior third of the pharynx, and shows no sign

of the peculiar armature seen in the Rhabditis of the closely-allied *Dochmius duodenalis*. This thickened posterior portion communicates with the mouth by means of a very delicate wavy tube, the musculature of which is comparatively weak. Its hinder end is encircled by the great central nerve ganglion, from which proceed forwards a number of fibres, beaded with smaller ganglion cells; the whole structure of the nervous system differing, in fact, in no way from the arrangements found in closely allied species, and therefore scarcely meriting any special notice.

The mature male *Rhabditis* attains or even exceeds $\frac{1}{16}''$ (1·7 mm.) in length, of which $\frac{2}{9}$ths is occupied by the pharyngeal portion of the digestive tube, the remainder being occupied by the intestine, testes and lemniscus. The anterior extremity of the body is much attenuated, while the caudal is so abruptly conical as to be almost truncate, all trace of the long lash-like tail of the earlier embryos having disappeared. The copulatory spiculæ and the common opening of the spermatic ducts and intestine are placed very close to the end of the body. There is no copulatory bursa or expanded membrane of any kind; but, in place of this, the worm is provided with a powerful clasping apparatus, consisting of four recurved hooks placed along the sides of the aboral extremity of the body. The hindmost pair of these is much the largest, measuring about $\frac{1}{800}''$ (0·034 mm.) long, and being placed just in front of the copulatory spicules and about $\frac{1}{250}''$ (0·1 mm.) from the caudal extremity. The other three pairs are subequal, and only about half the length of the hindmost; the second being placed only about $\frac{1}{800}''$ (0·034 mm.) in front, while the other two pairs are placed fully $\frac{1}{400}''$ (0·068 mm.) apart.

The fully grown females measure from $\frac{1}{12}-\frac{1}{10}''$ (2—2·25 mm.) in length, and closely resemble the males in all points, except in their greater size and in the absence of the clasping hooks. They are about $\frac{1}{200}''$ (0·136mm.) thick at their greatest diameter, *viz.*, opposite the generative opening, which is placed rather nearer the caudal than the oral extremity of the body.

That they are truly only the free stage the parasitic *Sclerostomum tetracanthum* is shown, not only by their having been traced in all stages from undoubted eggs of that parasite, but also by the absolute identity in appearance and size of the ova of both stages. The eggs, however, of the free stage are, at the time of deposition, always in a much more advanced condition than those of the parasitic stage, nearly always containing a lively embryo, so that ova exactly similar to those met with in horse-dung can only be found within the maternal oviducts of the Rhabdites. They give birth to a considerable number of ova, but do not approach the parasitic stage in prolificness. In no case did I observe any of the ova to hatch out within the body of the female, and her progeny resemble in all points the embryos hatched out from the eggs of the parasitic stage of the worm.

In this description I have, as far as possible, avoided, going into too minute

details, as to do so not only should I have to repeat much of what I have recently written on the subject of *Dochmius duodenalis*, but, after all, beyond a few measurements, no descriptions of organisms such as these can equal fairly executed plates, and several drawings of various stages of the free stage will be found appended to this paper, which, being made with the camera lucida, can be vouched for, at least as to accuracy of outline.

Considering that ordinary grasses and other forage plants form the habitat of the *Rhabdites*, the method by which they gain access to the intestinal canal of herbiverous animals is perfectly obvious, as the worms cannot fail to be swallowed along with the infested plants. Once the embryos have so invaded a suitable host their remaining life-history is already fairly well known, and is described in some detail in Cobbold's "Parasites," page 374, *et seq.*[1] As therein described, there can be no doubt that the worms, as the first act of their parasitic life, bore into, and encyst themselves in, the intestinal submucosa, and there acquire the peculiar four-spined mouth armature, and undergo the initial stages leading up to sexual maturity.

Cobbold (1879) states, on the authority of Leuckart, that these cysts are limited to the cœcum and colon, a mistake natural enough, as the latter authority had had only a single opportunity of examining a case; but, as a matter of fact, they may also be frequently found encysted in enormous numbers in the walls of the stomach, and, even when not found there at the time of one's examination, plain traces of their previous presence may be met with in nearly every case in which they are at all abundant in the lower bowel. These lesions consist in cicatricial changes marking the site of the deserted cysts, and vary in character according to the length of time that has elapsed since they were occupied. Immediately after the worms have escaped, the cysts will be found to be filled with fresh blood clot, and subsequently, as the clot decolourises and shrinks, they become little nodules of caseous-looking matter, surrounded by a zone of infiltrated tissue. Finally the contained mass becomes very small, and may calcify, but the infiltrated zone remains for a long time as a thickened nodule, of almost cartilaginous consistency, feeling much like an inbedded small shot. Where, as is often the case, the scars of the deserted cysts are packed closely together, a mammillated appearance results, together with a general thickening of the walls of the organ, which is extremely characteristic, and, once seen associated with recently escaped worms, is easily recognised as a sequel to their residence, even when no worms, either free or encysted, are to be found in the organ at the time of examination.

Sections of the affected organ showed that the functional efficiency of the often large areas of its surface affected must be almost abolished; for a large

[1] *Vide* also "Description of *Strongylus Arnfield*" (Cobb.) with observations on *Strongylus tetracanthus* by T. Spencer Cobbold in Trans Lin. Soc. 1886, pp. 284—93. On page 291 will be found a good account of the bibliography of the species.

portion of each section was seen to be occupied by cicatricial tissue, often placed so superficially as to entirely block up the openings of the peptic glands. When first I met with these gastric worms, the wide difference of their habitat from those first met with in the lower bowel made me suspect that I might have to do with a distinct species; but a subsequent close comparison of specimens from each situation convinced me of their specific identity, and, though it is extremely rare to find any of them in the small intestine, I have since met with a few specimens apparently on their way from stomach to colon, and also a few stray, scattered worms encysted in the submucosa of this portion of the bowel. While, however, this latter occurrence serves as a connecting link between the two commoner situations, it is so exceptional that it must be considered abnormal.

Although the submucosa of the stomach, and occasionally of the small intestine, serve as localities for the encystment of the young parasites, the conditions met with within the lumina of these viscera do not appear to be suitable to their prolonged residence when they have escaped from their cysts. None of the worms found free within the stomach had attained their full growth, and as, to all appearance, they do not take up the habit of blood-sucking until quite fully grown, no worms will be found adherent to the wall of the stomach, even in a body opened immediately after death.

In the great intestine too, besidesf ully grown worms gorged with blood, and still adhering to the mucous membrane, much greater numbers of smaller ones will be found free in the bowel, whose intestines show no evidence of blood-sucking propensities. These smaller worms seem to subsist on the nutritive fluids with which they are surrounded, and are never, so far as I have seen, to be found adherent to the mucous membrane.

Though not fully grown, these small worms are sexually mature, and may so often be found in copula that it is rather the rule to find them so than otherwise, and the adhesion between the couples is so firm that hardly a doubt can be entertained that their union is assisted by some viscid secretion. Indeed the fact that it persists long after the death of the worm, when all muscular contraction must have ceased, almost proves this to be the case. All worms met with, free in the intestine, whether full-grown or otherwise, are sexually mature, though it is possible that they may not begin to lay their eggs until, with complete growth, the power of gaining a more abundant supply of nourishment is acquired.

It is while encysted that the changes that lead up from the already described Rhabditis progeny to sexual maturity take place, and hence the statement in Cobbold's "Parasites" (*fide* Leuckart) that "The development of the sexual apparatus had not yet commenced is a mistake, arising probably from the limited material for observation at his command. So far from this being the case, it is rare to find an encysted worm in which the sex cannot already be made out, provided attention be paid to the position of the rudiment of the

generative gland; and all stages, from indeterminate Rhabdites still provided with the hollow styloid mouth armature, to sexually mature parasites, just ready to escape with a nearly complete dental apparatus are to be found. The specimen figured for example, though far from sexually mature, is quite clearly a female, the generative aperture being already clearly discernible about the middle of the body, though the generative gland itself, as far as its histiological elements are concerned, might be either testis or ovarium. In spite of this, taken as a whole, the sex of the animal might be diagnosed from an examination of the gland alone, for the most advanced cells are placed in the middle of the organ and not at the aboral extremity, as would be the case in a male histologically indeterminate gland.

While encysted, the little worm undergoes several changes of skin, and, by the time it is ready to escape, is fully equipped with the peculiar mouth armature of the adult. The buccal cup first appears as a quite unarmed cavity. Next, the circlet of minute denticles, that comes behind the circlet of fimbriæ in the adult, is developed. The four labial spines next appear, but are rather papillæ than spines at this stage; and, finally, the circlet of fimbriæ and the ring of plates round the pharyngeal opening, made their appearance. Probably more than one ecdysis is undergone by the worms after escaping from encystment, for specimens undergoing the process are not hard to find, though I was unable to satisfy myself of the occurrence of the so-called cocoons described by Cobbold.

Appearances that might be interpreted somewhat in this fashion I have indeed met with; but they appeared to me to be better explicable as accidental accumulations of fæcal matter round a worm undergoing ecdysis. Nematodes undergoing this process are always in a very sluggish state, and so would more readily serve as the nuclei of such concretions than the actively moving creatures they are when not so engaged; but I must repeat that I look upon the occurrence as purely accidental, as worms changing their skins were far more commonly to be found without any such encumbrance than with it.

Thus it will be seen that, during the life-history of this worm, it inflicts two serious lesions on the intestine. First, it bores its way into, and encysts itself within the substance of the mucous membrane, setting up changes which result in the certain impairment, and often entire loss, of functional activity in the little patch of digestive mucous membrane affected; and secondly, it, with the powerful teeth of the fully grown worm, gnaws into the mucous membrane and continuously sucks its victim's blood, and, as the period of sexual vigour during which the worm exhibits this blood-sucking propensity is probably a tolerably long one, this second class of lesion is one which must be again and again inflicted by the same worm.

In the face of these facts it appears difficult to understand how any one can doubt the ability of this parasite to bring about a fatal result.

No one now doubts the ravages wrought in the human subject by *Dochmius duodenalis*, and yet the equine parasite is absolutely much larger, and, even relatively to its larger host, at least as large as the human scourge; added to which, it is generally present in numbers which put the worst cases of anchylostomiasis into the shade.

Cobbold, indeed, recognises that it has caused "virulent epizootics" in England; but, in spite of his teachings, the pathological importance of the worm appears to be but little recognised, at any rate in India.

Shortly after I had made out that the so-called "Surra" among the transport animals at Shillong was really sclerostomiasis, I wrote a short letter to the "*Pioneer*" with the view of ascertaining whether or not similar cases had been met with elsewhere.

My object was to collect information through ordinary correspondence, and nothing was further from my intention than to enter into a public controversy, at any rate in the columns of an ordinary newspaper, which, though well suited for a notice of enquiry on any subject, is recognised as hardly a suitable medium for a discussion of so essentially technical a character. In place, however, of sending me the results of his experience in letter form, Mr. Steel, the well known and learned head of the Veterinary College at Poona, replied in the columns of the "*Pioneer*" in a way that showed he entirely misunderstood me, for he was clearly under the idea that I had propounded the thesis that all "Surra" was sclerostomiasis, whereas all I had asserted was that certain cases which had fallen under my own observation, and were shown me as instances of that disease, were of that nature, and had asked for information as to the prevalence of the parasites elsewhere.

I have no desire to re-open a controversy based entirely on a misconception of my views, nor should I allude to the incident here were it not that Mr. Steel's letter may, I presume, be taken to fairly represent current veterinary opinion on the subject, and he definitely commits himself to the assertion that the strongyles in question are "inadequate to explain the phenomena of Surra."

Now, as I gather from Veterinary Surgeon R. W. Burke's excellent little work on "The tropical diseases of the Horse," the characteristic phenomenon of "Surra" is an inexplicable pernicious anæmia; in fact, his chapter on the subject is headed "Surra, or pernicious Anæmia," and the adequacy of these strongyles to bring about a pernicious anæmia is a matter on which incredulity is difficult to understand.

It may be, however, that Mr. Steel's meaning is that the existence of the strongyles will not explain the presence in a large proportion of cases of the so-called "Surra parasites" (*Trichomonas Evansi*), and of course there can be no possible connection between the two organisms; but, until these monads have been cultivated apart from their host, and a pernicious anæmia produced in a healthy animal by infection with a pure cultivation, the connection between monad and disease must remain a mere matter of opinion.

As is well known, these monads are congeneric, and more than probably conspecific with certain morphologically identical organisms found hy Crookshank and others in the blood of healthy rats, and if they be really so harmful to horses, the immunity of the rats is very hard to explain. So that whatever proportion of the group of cases popularly called "Surra" may be attributable to sclerostomiasis (and it is very probable that several distinct causes of pernicious anæmia may contribute to the total), I should personally prefer to look upon the coincidence of the presence of monads in the blood as accidental, until a rigid demonstration of a causal connection be forthcoming. The most that can be said of the researches of Evans, Steel, and others on this point is that they are suggestive of the possibility of a causal connection between the monads and the particular set of cases under their observation.

This applies especially to their inoculation experiments, which, being conducted with blood, might bring about deaths by some form of septicæmia; and, putting this aside, it must be remembered that such a fluid, besides the monads, might contain some unsuspected *bacterium* which might yet be the true cause of the fatality in the group of cases they were observing.

I regret to say that I got but few communications in reply to my query in the "*Pioneer*"; but those I did receive are sufficient to show that the strongyles in question are very common in Burma.

Of especial interest were two letters I received from Dr. Hendley, who was associated with Dr. Evans in his researches on "Surra" in Burma.

Dr. Hendley is, of course, strongly predisposed to the view that the fatality in the cases he observed was referable to the *Trichomonas Evansi*; but the following passages are remarkable, as they clearly show that entozoa were present in some at least of their cases. He says: "In the first cases examined we noticed large numbers of small, round, whitish worms, from half to one and half inches long, imbedded in clusters in cyst-like spaces in the stomach and associated with them, but often without them, ulceration of that organ. These conditions were found in old standing cases, and at first led us to believe that they might be the cause of the disease. However, we discarded the idea when they were not found in cases killed earlier in the course of the complaint. At this lapse of time I cannot say that the whole length of the intestine was slit open in each case; but the examination was generally fairly thorough."

Elsewhere Dr. Hendley remarks: "The stomach and liver appear to be the organs most affected in the body, and ulceration, due to progressive anæmia in the former organ, is one of the most important *post mortem* appearances in long standing cases."

Now, the condition of the stomach here described is thoroughly characteristic of sclerostomiasis; and that worms should be found actually in the stomach in only a small proportion of cases coincides exactly with what I have observed at Shillong, while marks of their previous presence were found in every case

examined. The worms he describes were, it is true, possibly not *S. tetracanthum*, but either *Spiroptera megastoma* Rudolphi or *Strongylus Axei* Cobbold, but the ulceration and other appearances correspond exactly with those produced in the stomach by undoubted *S. tetracanthum* at Shillong; so that I cannot but think that, had the cœcum and colon been uniformly examined, they would have discovered strongyles in a far larger proportion of cases than they did in the stomach, or, in other words, that a certain proportion at least of their cases were no more nor less than instances of sclerostomiasis.

As to the prevalence of the worm in Burma, I obtained further, and unequivocal evidence from another correspondent, Captain Hutchinson, commanding the Ye-u battalion of Military Police. He informs me that his corps suffered terribly from "Surra" in 1889, only three ponies surviving out of 176.

The outbreak was coincident with the ponies, while on service, being necessarily allowed to graze in the jungle, instead of being fed on hay, as had previously been the case; and cases have continued to occur up to the present time.

Captain Hutchinson, having noticed my letter in the "*Pioneer*," examined the intestine in the next case that ocurred, and found it swarming with worms, some of which he sent me, and I found that they were, like those found in the Shillong outbreak, *Sclerostumum tetracanthum*. Captain Hutchinson's authority for looking upon the outbreak as one of "Surra" was A. V. Frost, Esq., the Veterinary Inspector of Burma, who had been deputed to enquire into the cause of the outbreak, and whose report on the subject he was good enough to send me. In this report I could find no mention of any examination having been made of the intestines of the affected animals, and indeed, in his letter, Captain Hutchinson remarks: "I regret that last year neither myself, nor my salutri, or Dr. Frost examined the intestine." In his report the Veterinary Inspector states that, out of eighteen animals whose blood he examined he found the *Trichomonas* in fifteen, but in all "the ulceration of the stomach was found to be very well marked." Now ulceration of the stomach is, as has already been remarked, one of the most characteristic of the pathological appearances found in *Sclerostomiasis*, and the life-history of the parasite furnishes obvious reasons why this should be the case. On the other hand, whatever may be the pathological effects caused by the presence of the *Trichomonas Evansi* in the blood, it is very difficult to see any possible reason for their bringing about ulceration of the stomach, and hence one is forced to the conclusion that in these cases the true cause of the lesion was overlooked; the fact being that, once the assumed cause (*i.e.*, the monad) was found to be present, any further examination was assumed to be superfluous. It is right, however, to record that some of the cases described by Captain Hutchinson appear to be referable to what is usually spoken of in India as anthrax; although I understand from Dr. D. D. Cunningham, F.R.S., that its identity with the anthrax of cattle in Europe is a matter of considerable doubt.

Of the prevalence of the parasite in parts of Assam outside the Khasia hills, I obtained evidence in a very interesting letter from Dr. Rudduck of Meesa.

Some years ago he had lost several horses from "Surra" and, on making a thorough examination, he found the only obvious cause of death was the presence of immense numbers of small worms in the cœcum and colon. He preserved some of these, and sent them to "a well known veterinary firm in Calcutta," who reported that two species were present, one of which was the common *Oxyuris curvula*, and the other was "unknown."

The pressure of other work prevented Dr. Rudduck from following up the investigation, and hence he did not publish, or make any further effort to ascertain the character of the "unknown" species; but, when visiting me in Shillong, he at once recognised my specimens of *Sclerostomum tetracanthum* as being identical with the unknown species that had played such havock in his stables.

Few in number though they be, these communications go far to prove the prevalence of the parasite throughout Assam and Burma, and, wherever prevalent, a severe fatality among their equine hosts follows as a necessary consequence.

Further, the very paucity of the number of communications clearly demonstrates how little attention has been bestowed upon parasitic disease among animals in India. Whether these cases should rightly be called "Surra" or not is a matter of the smallest moment; the important fact remains that the parasite in question is a source of serious mortality among equine animals in the tracts of country mentioned; and all that remains to be considered is how far the recognition of this fact can help us in the treatment and, more important still, in the prevention of the malady.

In the treatment of a disease such as that under consideration the importance of forming an early diagnosis is obvious, for the injury caused to the digestive organs by the prolonged presence of the parasites is so serious that the mere expulsion of the worms at a late stage of the disease cannot be expected to effect a cure, as the injured organs will have become incapable of assimilating fresh food to make up for what has been lost. Hence, in countries where these worms are known to be prevalent, animals should be carefully watched and treated promptly, more especially in the direction of preventing further infection. Pressure of other work made my clinical observations scanty and incomplete; but, so far as they go, I am inclined to think that irregular feverish attacks form one of the earliest indications that something is amiss. These feverish attacks, I take it, are brought about by the migration of successive batches of parasites into the submucosa.

As the initial lesions are quite identical with those caused by *Trichina spiralis*, in which the boring of the parasite through the intestinal wall almost uniformly determines feverish symptoms, this is only what might be expected.

Hence attacks of fever, occurring in equine animals in any region infected

by the parasite should be viewed with suspicion, and measures taken to ascertain its presence or absence, and owing to the immense numbers of ova produced by them, the determination of this point, by microscopical examination of the dung, is a perfectly easy matter. Owing to the large size of the ova, the lowest powers suffice for the purpose, and the readiest way of making the examination is to stir up a little of the dung in a shallow glass tray containing water, by which means a comparatively large quantity can be searched over in a short time. The measurements and microscopic characters of the ova have already been described, and so need not be repeated here.

It is probable that each successive invasion of parasites, in other words, each infected meal that the animal consumes, will be followed by a feverish attack, and some temperature charts which I saw at Shillong, as well as one supplied me by Dr. H. Hendley as illustrative of the outbreak of "Surra" observed by him in Burma exhibit just such traces as one might expect from a necessarily irregular cause of pyrexia such as this. In Dr. Hendley's chart, reproduced below, dates of observation as to the presence or absence of *Trichominas Evansi* are carefully noted; but I confess I am unable to trace in it any relationship whatever between the pyrexia and the presence or absence of the nomads in question.

Taking the positive observations we find they are placed as below :—

1st Note.—Temperature nearly normal between two steep rises. Present for one day.

2nd ,, At apex of a rise. Present two consecutive days.

3rd ,, Temperature fluctuating a little above the normal. Presenttwo consecutive days.

In nearly all the negative observations the temperature, as in the third positive one, is fluctuating a little above the normal.

Such a trace might of course result from any irregularly acting cause of pyrexia, and I merely draw attention to it in this connection with the view of pointing out that, while the relationship between the course of the temperature and the presence or absence of the trichomonads is by no means obvious, it is in no way incompatible with what one may expect to find in sclerostomiasis.

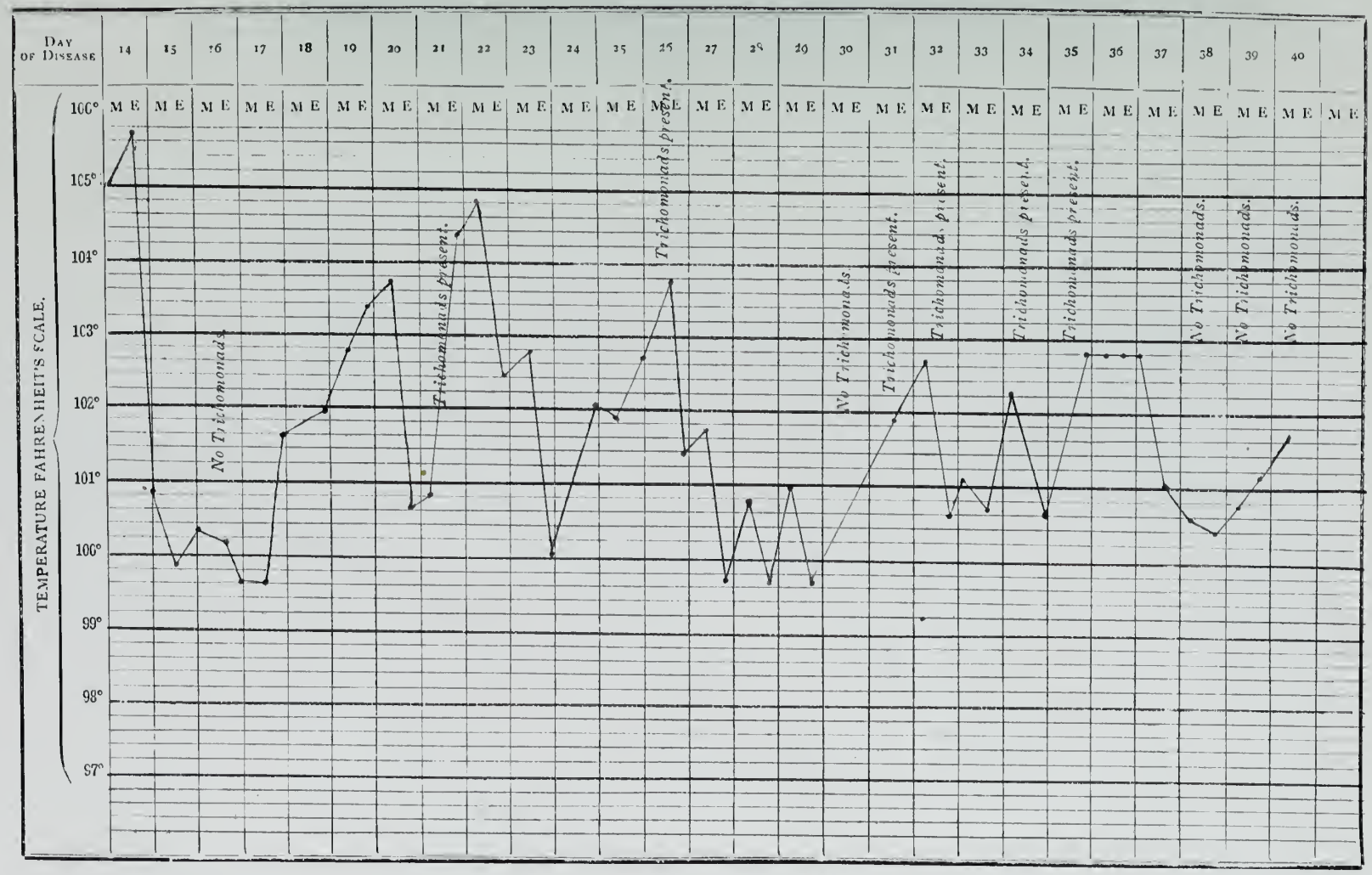
In the chronic stage of the disease, *i.e.*, after the parasites have effected a lodgment, the main symptoms are loss of condition and marked anæmia, best observable on the mucous surfaces of the tongue and conjunctiva.

In the last stages of the disease the temperature is often subnormal.

Assuming the diagnosis to be established, the obvious indication is to expel the worms as quickly as possible; but here my experiences are limited to a single case. I can lay no claim whatever to any knowledge of veterinary medicine, and hence I did not care to institute therapeutic experiments on animals belonging to other folks.

It is quite obvious, however, on general considerations, that no remedy can

Temperature Chart of one of Dr. Hendley's cases of "Surra", in which the animal died on the 53rd day of the disease, eighteen days after the last recorded observation of Trichomonads.



be expected to exercise any effect on the encysted worms, and hence, until they return to the lumen of the intestine, all attempts at their expulsion must be hopeless. So far as I know, we have no data at present at our disposal for estimating the duration of the period of encystment; but, practically speaking, worms in both stages will be present in the majority of cases, and treatment must hence resolve itself into the prevention of re-infection, combined with the periodical administration of anthelmintics in order to expel any worms that may have escaped from encystment before they have time to attain complete maturity, and with it the habit of sucking their victim's blood.

In the case of my own pony I administered 1½ oz. thymol in three doses of ½ oz. each, and the result, as I afterwards found, was to expel nearly every free worm. Ova, however, soon re-appeared in the dung, and believing at the time that this was due to inefficient action of the remedy, owing to its having to reach the lower bowel before it could exercise its action on the worms, I determined to make an attempt to introduce the remedy direct into the colon. I accordingly made an emulsion of thymol by adding it, in spirituous solution, to water, and injected it directly into the colon by means of an aspirator needle. Further, suspecting the original dose might have been too small, I increased the quantity to 2½ oz.

The animal seemed in no pain, and grazed naturally for some time after the operation; but within a few hours toxic symptoms appeared and the animal died, the phenomena presenting a general resemblance to those of carbolic acid poisoning.

Post mortem, it was only after considerable search that the puncture could be found; but it was quite obvious that the whole of the emulsion had passed into the colon.

There was not the least sign of the characteristic smell of the drug to be detected in the peritoneal cavity, and the neighbourhood of the puncture was quite free from redness. In the bowel, enormous numbers of the worms were found in the encysted stage, but only a very few free. There were, however, large numbers of amphistomes, and all these, as well as the few sclerostomes present, were dead for a considerable distance from the point of injection, as far, in fact, as the remedy might be expected to be carried by peristalsis during the time that had elapsed between administration and death. The fatal result was therefore clearly traceable to the largeness of the dose, and not to its method of administration, and, in suitable doses, I still hope that the direct action of the remedy so administered might be taken advantage of, though there can be no absolute need of it, as the result showed that the original dose, administered by the mouth, had acted quite efficiently; and it seems to me that our best hope lies in the repeated administration of this most catholic of all vermifuges, combined with generally supporting treatment, and the administration of easily digestible articles of diet.

Owing, however, to the process of encystment being by far the most formidable source of harm, and the impossibility of touching this by any drug, remedial measures are of quite secondary importance compared with those of prevention; and here the course to be pursued is perfectly obvious, though our success in following it must depend entirely on the means at our disposal.

As it is perfectly clear that infection can only be spread through the agency of the dung of affected animals, the exclusion of all equine animals from the land from which our fodder is derived will alone suffice to stamp out the disease. Hence, in large establishments, the acquisition of grass reserves on which this measure can be carried out is of primary importance; and, for large stables, the establishment of cinerators, in which the dung of all animals may be destroyed by fire, is a further measure that must suggest itself to all who consider the question.

Again, I have experimentally ascertained that temperatures exceeding 140°F. are fatal to the *Rhabditis*, and hence, where the establishment of protected grass reserves is impossible, immunity may be secured by the exposure of all articles of food to this very moderate temperature. For the private owner an apparatus like the ordinary domestic "hot case" for warming plates and dishes would suffice, while a moderately-sized room fitted so as to be well closed and provided with a furnace and flue would suffice for even large establishments. Such a chamber would cost but little either to construct or to maintain, and would amply repay the cost and trouble, in any country where large losses are referable to this disease. It is, by the way, a notable matter that Dr. Hendley informs me that they found that cooking all the food, even to the grass of their equine patients, by far the most effectual agent in treatment, and the fact of their having been able to carry out the system, shows that the difficulties are by no means insuperable.

I must now bring this paper to a close, and fear that I have already trespassed too much on the reader's patience, my only defence being that, though it has run to a larger number of pages than I at all intended, I have done my best to convey my meaning as briefly as possible.

Quite recently I noticed in the columns of one of the daily papers a notice that the question of "Surra" was under examination in the new Bacteriological Laboratory at Poona, and that their investigations had resulted in the discovery of a "bacillus." I await with interest the publication of the results of this investigation, which, if correctly reported, must imply the discovery of a class of cases under the common designation of "Surra" of quite a different character from those affected either by strongyles or by the *Trichomonas Evansi*, assuming the latter, for the moment, to have a causal connection with some of the cases so called.

I hope, however, the investigators will be careful to entirely exclude the

action of macroscopic parasites, by a systematic examination of the intestinal canal and its walls.

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In Medical Charge, Lawrence Military Asylum,
Sanawar.

SANAWAR;
The 31st January, 1891.

Explanation of Plates.

FIG. 1.—Ovum of *Sclerostomum tetracanthum* from maternal oviduct.

,, 2.—Another in the stage of development usually met with in fresh horse-dung.

,, 3. } Further developed ova from cultivations; the latter contains a well-deve-
,, 4. } ‡ loped embryo.

,, 5.—Line $\frac{1}{1000}$″ long on same scale as preceding figures, *i.e.*, × 440 diams.

,, 6.—Recently hatched embryo. Those of the parasitic and free stages are quite identical at this stage.

,, 7.—A further developed Rhabditis, 6 to 8 hours after hatching out.

,, 8.—Another specimen two days old. At *A*, a spindle-shaped body, the rudiment of the generative gland, may be observed.

,, 9.—Scale of $\frac{1}{1000}$ths″ at same amplification as figs. 6, 7, 8, 10, 12 and 13.

,, 10.—Very immature female Rhabditis, about a week old, from a cultivation in the open—

i, intestine.
o, ovary.
v, genital aperture.

,, 11.—Nearly mature male Rhabditis from forage plants.

,, 12.—Oral extremity of the same, more highly magnified, to show the peculiar styloid mouth armature.

,, 13. Caudal extremity of the same to show the clasping spines—

i, intestine.
f, spermatic duct.
c, *c*, clasping spines.
s, copulatory spicula.

,, 14. Scale of $\frac{1}{1000}$ths″ at same amplification as figs. 11 and 15.

,, 15. Mature female Rhabditis from forage plants. The specimen has almost completed the process of laying her eggs, so that comparatively few ova (disposed in single file) are left.

g, œsophageal ganglion.
p, pharyngeal bulb.
l, lemniscus.
i, *i*, intestine.
v, genital aperture.

,, 16. Immature specimen of parasitic stage from a submucous cyst. The generative gland is histologically indeterminate; but the circumstance of the most developed cells being placed in the middle of the gland shows the specimen to be a young female.

,, 17. Scale of $\frac{1}{1000}$ths″ at same amplification as fig. 16.

,, 18. Oral extremity of the same specimen, more highly magnified.

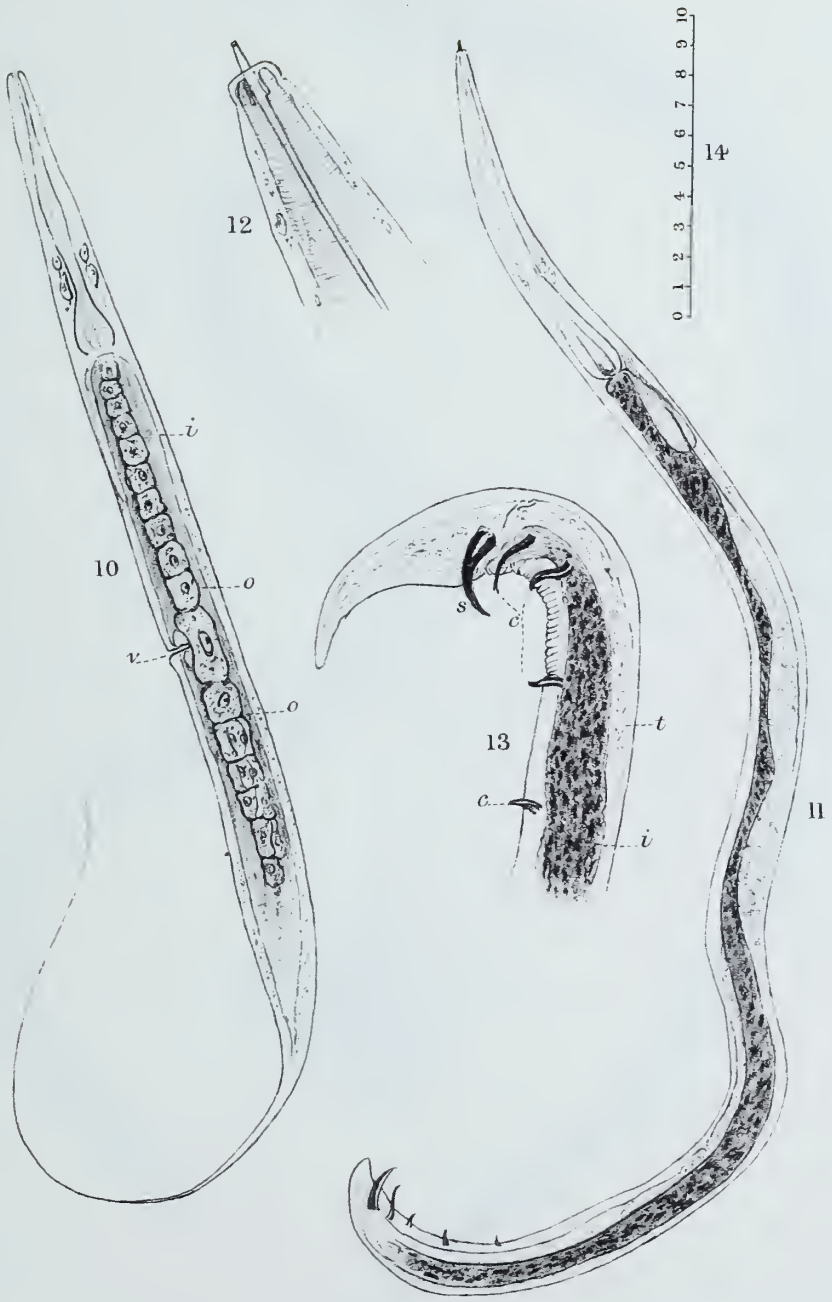
,, 19. Scale of $\frac{1}{1000}$ths″ at the same amplification as fig. 18.

PLATE I.

G. M. G. de nat. del.

Reg. No. 333, San., India—Sept. 91.—300.

Litho., S. I. O., Calcutta.



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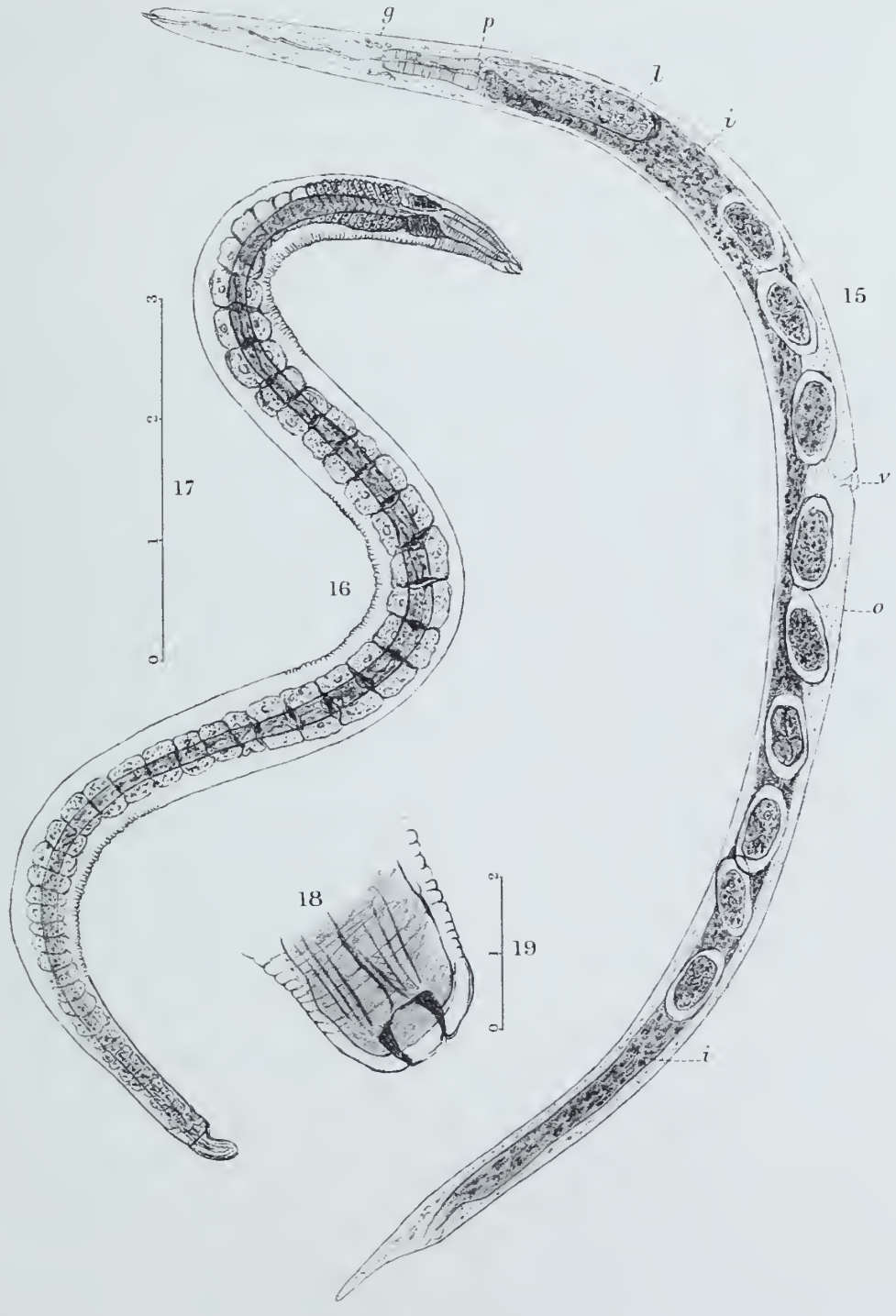

G M G de nat del.

Reg No 333 Surv., India—Sept 91—300

Litho., S. I. O., Calcutta.

On a new Sclerostome from the large intestine of mules (a postscript to the preceding paper).

BY

SURGEON G. M. GILES, M.B., F.R.C.S.,

INDIAN MEDICAL SERVICE.

SINCE writing the above, a more careful examination of the materials obtained from the mules that died in the so-called epizooty of "Surra" at Shillong, has resulted in the discovery that the larger worms, found so abundantly in company with *Sclerostomum tetracanthum*, are not, as I supposed, all large specimens of that species, or of *Sclerostomum equinum* (Rud.), but examples of a species which has not, so far as I can discover, been hitherto described.

Although they never rivalled *S. tetracanthum* in abundance, they were yet so numerous that reflection should have shown that no large proportion of them could be examples of *S. equinum*, as thousands must have been present in several of the cases, and, to account for so large a number, the mesenteric arteries should have been a mass of aneurisms; whereas, in only one case, were these found, and in this only two small ones, which could hardly account for the presence in the intestine of more than a score or so of the mature parasites.

The species I am about to describe is intermediate in size between *S. equinum* and *S. tetracanthum*, averaging scarce half the length of the former, but is proportionally very stout, and the characters of the mouth armature, and of the bursa copulatrix are quite sufficient to establish its specific distinctness. As, however, the three species are closely allied to one another, I append descriptions, with original figures, of the other two, in order that their differences and resemblances may be the more exactly appreciated.

The new species is a vicious blood-sucker, and was always found gorged with blood, and generally firmly fixed to the mucous membrane. A very large proportion are always to be found firmly joined together in pairs *in copula*, the grip of the male hood being assisted by a glutinous secretion, so that it takes some little careful dissection to separate them. As, in size, it bears at least as large a proportion to the bulk of a horse or mule as *Dochmius duodenalis* does to that of a man, and as it is often present in even larger numbers, it must be capable, by mere depletion, of doing incalculable harm to its host, and it may be doubted whether the caseous infiltration of the intestines brought about by

S. tetracanthum, combined with its weaker depletory efforts, had more to do with the death of some of the animals examined than the loss of blood occasioned by this larger species.

It is likely enough that this species too encysts, as all met with were mature; but the *Trichonemes* would probably be indistinguishable from those of *S. tetracanthum*, which was always associated with it, and it would require a case in which this species was alone present to establish this point, and to make out any differences that may exist between their *Trichonema* stages. Their free stage life-history is also probably similar; but from the size I have recorded for the ova, I am satisfied that it was at any rate mainly with *S. tetracanthum* that my cultivations were concerned.

Description.—*Sclerostomum robustum. sp. n.*

Male about 13 mm. long by 0·8 mm. at the thickest part, which is situated about the middle of the body.

Female about 22 mm. long by 1·1 mm. at the thickest part, which is a little in front of the middle of the body.

The male is more tapered anteriorly than posteriorly, while the female is equally so. Both sexes are usually tinged a rather deep reddish brown from the blood on which they feed. Head subglobose, with a slightly constricted neck.

The margin of the oral aperture is irregularly tuberculated, and carries four papillæ armed with soft setæ, which, from the large nerve fibres that can be traced to them, are probably tactile in function. Within the tubercular margin is a circlet of vertically placed denticles forming a trephine, like that of *S. equinum*, only the teeth are much larger and less numerous (about 18). Within this, guarding the oral aperture, are a series of horizontally placed fimbriæ (about 48 in number). These almost meet in the centre, so as to nearly close the opening of the mouth. Below this, is a cup-shaped cavity which ends below in the opening of the thick muscular pharynx, within the entrance of which are three powerful, exactly similar teeth. Each of these teeth presents a falciform crown, placed on a considerably longer and stouter root, which latter is fixed in a sort of sheath-like pocket of the pharyngeal wall. They are probably capable of being protruded.

The bursa copulatrix of the male is markedly bilobed, no trace of a median lobe being present, though the dorsal fissure is not very deep. Ventral costa bifid, combined with the ventro-lateral, and lateral costæ to form a group, the lateral consisting of two subequal branches, with occasionally a smaller branch placed near their roots on the dorsal edge of the costa. Dorso-lateral, and dorsal costæ alike deeply bifid, and combined together to form a group of four, of which, the most anterior division of the dorso-lateral is considerably the largest, while the remaining three are subequal. Caudal extremity of female, rather abruptly mucronate: anus close to the point of the tail: vulva about one millimeter in

front of it. Ova very large, of regularly elliptical outline, 0·152 mm. in length × 0·082 in breadth; laid as a morula.

Sclerostomum equinum (Rud.)

I will first quote the description given in Diesing,[1] and will then add some fuller details derived from the examination of a male specimen, from a verminous aneurism of the mule :—

"CAPUT *globosum truncatum; os limbo denticulis rectis dense armato.* CORPUS *rectum retrorsum aitenuatum, bursa maris triloba, lobo intermedio minore, lobis singulis quadriradiatis, radiis lanceolatis; extremitate caudali feminæ obtusiuscula, apertura genitali in tertia parte corporis postica.* OVULA *elliptica medio constricta.* COPULA *sub angulo recto admissa.*

Longit. mar., 1″ (26 mm.); fem. 1½—2″ (—52 mm.)."

Unfortunately I was unable to find among my materials any mature intestinal specimens; but the specimen taken from an aneurism agreed in all points with the above descriptions except, of course, that, in length, it coincides with the measurements he gives for his Var. *Minor aneurismaticus.* The most advanced intestinal specimens of *S. equinum* that I have been able to discover among my collections are still far from mature, and differ in no way save in size from the aneurismal specimens described below. Only a very few ova approaching maturity could be found, and these wanted still the median constriction, and had evidently not reached their full size, being about the size of the ova *Dochmius duodenalis*, measuring but 0·067 mm. in length.

In the specimen figured, the margin of the mouth carried six, nearly equidistant, tactile papillæ, exactly similar in structure to those of the previous species. On one side, showing through the skin, may be seen a long powerful buccal tooth, shaped like a rat's incisor. Within the six marginal papillæ is the circlet of the boring trephine, which is armed with minute, but proportionally stout, semi-circular teeth. Within this again are the horizontal fimbriæ, guarding the opening of the mouth, which are exactly similar in number and form to those of the preceding species. The buccal cavity too is of nearly the same form, though rather more funnel-shaped; while the armature of the entrance of the pharynx is quite different, and very peculiar.

This consists of two great teeth; but, instead of being arranged at equal intervals round the entrance of the pharynx, they are placed, one behind the other, on the same side. The outer tooth, the form of which has been already described, is enclosed in a sheath, formed in the wall of the buccal cavity; while the inner tooth forms an unilateral projection from the margin of the opening of the pharynx.

This latter is bidentate and nearly three times as wide as the outer tooth, though less than half as long. It is very stoutly made, and carries on its axial face a low ridge, irregularly tuberculated on both edges, running down from the

1 Diesing: Systema Helminthum (1851), Vol. II, page 303.

notch between the dentations, and broadening out below, where it meets the circlet of denticles guarding the actual entrance of the pharynx. These last consist of a circlet of chitinous plates, rather larger than those of the triphine, but of very irregular shape, especially those on the side opposite to the great tooth.

The male bursa copulatrix is, as will be seen from the figure, markedly trilobed, the lateral lobes being rounded, while the median lobe is pointed, though somewhat abruptly so. The ventral and ventro-lateral costæ form a group almost exactly similar to that formed by the corresponding costæ of the preceding species. The dorso-lateral consist of one large and one small branch, which embrace between them the notch between the median and lateral lobes; while the dorsal costæ are also represented by two branches, the inner of which has a small rudimentary branch on its inner margin, rather nearer its root than its point.

Sclerostomum tetracanthum Dies.

Descriptions.—This species differs considerably from the preceding, and is, in some respects, more nearly allied to *Œsophagostoma columbianum*, an ovine parasite, to be described below, as the cause of nodular disease of the intestine in sheep. This resemblance is most marked in the arrangement of the parts about the external mouth opening; but, at the same time the two species cannot be considered to be congeneric, as the present species has a shallow, but at the same time distinct, buccal cup; whereas in *Œsophagostoma* the armed peristome is followed immediately by the œsophagus.

Diesing's[1] description is as follows :—

"CAPUT *truncatum*; *oris limbo interno denticulis rectis densis, externo aculeis 4 majoribus obtusis cruciatim dispositis armato.*

"CORPUS *rectum utrinque attenuatum, bursa maris triloba, lobo intermedio valde producto, lobis singulis multiradiatis, radiis furcatis*; *extremitate caudali fœminæ recta, truncata, breve mucronata, apertura genitali supra caudæ apicem. Copula sub angulo recto admissa.*"

This description is quite sufficient to identify the species; but, for purposes of contrast with the other species, the following details may be added :—

Cobbold[2] remarks :—

"The fore-gut has a complicated structure, more strikingly so than has hitherto been stated. The mouth leads into a strong buccal cup, supporting a circular series of short bristles (described and figured by Schneider, but only indicated by a dark line in my (Cobbold's) drawing), which separately have an extreme length of $\frac{1}{760}$ of an inch. The cup rests upon a muscular ring, which also supports a circular row (o^1 in the present figure) of small chitinous processes. The ring is succeeded by an anterior œsophageal bulb the lumen of which is bordered by chitin plates (o^2 in the present figure).

1 DIESING: *Loc. cit.*, Vol. II, page 305.

2 DR. T. S. COBBOLD.—Journal Linn. Soc., London, XIX, 1886, pages 284—93. It is remarkable that Cobbold in this paper, which I have recently obtained, with true and scientific insight, actually foretells as probable some of the points established in the preceding paper.

"Then follows a broad muscular pharynx (*p* in the present figure), through which the narrow chitinous cylinder of the lumen (*sic*) glimmers distinctly, leading down to the somewhat broader posterior bulb, which also displays thick dental plates."

This description deals only within the mouth parts below the level of the "straight denticles" (*f* in my figure) described by Diesing, Schnieder's series of bristles being that marked (*b*) in my figure. Thus we have from without inwards—

First.—The four great labial spines, occupying the position of the tactile papillæ of the other species, but forming, in this, formidable weapons.

Next comes the rank of horizontal fimbriæ, present in all three species, and also in *Œsophagostoma columbianum* Curtice, described below. These fimbriæ are very characteristic of the sclerostomes, and are often described as teeth. They are, however, long thin plates, and do not in any way function as teeth, but rather as a sort of sieve, between the plates of which blood corpuscles and other fine particles suitable for food can pass easily, but which serve to exclude all the coarser intestinal matter with which the animals are surrounded.

We now come to the buccal cup proper, armed with Schneider's Bristles, and corresponding to the circlet of bidentate teeth of *Œsophagostoma columbianum*. The boundary between the buccal cup, and Cobbold's anterior œsophageal bulb is marked by a circlet of somewhat irregularly-shaped chitinous plates, mostly rather broader at their free edges than at their origin; and, in the same way, the junction of the bulb with the pharynx is marked with a second row of more regularly shaped plates, each of which consists of a flat, stout plate, of semi-circular outline, with a small tubercle forming a point to the crown.

The ova of *S. tetracanthum* have a very characteristic oblong outline, rather exaggerating the flattened sides, in fact, of *Dochmius duodenalis*, but are much larger, measuring 0·1 × 0·05 mm. They are usually laid as a many-segmented morula. Large as they are, they cannot possibly be mistaken for the very much larger and elliptical eggs of the new *S. robustum*.

The form of the male bursa varies considerably, while always remaining of the same type.

There is no distinct notch between the lateral and median lobes, as in *S. armatum;* but the median forms a bold curve back from the laterals and, especially in small specimens, is often prolonged to a long point. In other specimens again the median lobe is comparatively short and blunt. I figure two specimens, illustrating this variability, and neither is an extreme instance of the forms they represent. With this variability the relative lengths of the dorsal and lateral groups of rays also vary. Their arrangement, however, remains the same, the dorsal costæ being bifid, the outer divisions considerably shorter. They form, with the simple dorso-lateral, a distinct group.

The lateral, ventro-lateral and ventral costæ form two other compact, paired groups, in which the anterior division of the bifid lateral far exceeds the

other members of the group in size. Between the dorso-lateral and lateral costæ are deep and broad semi-circular hollows, which are occupied, on either side, by a single large granular cell, probably of glandular character. I can find no previous notice of this gland cell, which is very easily seen in many specimens, and can only with difficulty be made out in others, its variable prominence probably corresponding to various stages in its secretive functions; the cell full of secretion being easily visible, while that which has recently discharged its contents being with difficulty so. In connection too with variations in the bursa, it may be mentioned that Cobbold (*loc. cit.*) mentions the occasional presence of an additional branch to the dorsal costæ, which may be nearly as long as the primary branch itself.

The figures given in the plates are all from original camera lucida drawings, and can therefore be trusted for the purpose of obtaining measurements of the various parts represented. Combined with the foregoing descriptions I do not think that any difficulty need be found in distinguishing the three species; nor do I think that any doubt can be felt of their specific distinctness.

At the same time, while to minute examination the differences are sufficiently obvious, it is by no means easy to distinguish between the three species by mere naked-eye examination. Between full-sized specimens of *S. equinum* on the one hand, and small specimens of *S. tetracanthum* on the other, *S. robustum* is easily distinguishable; but, in all three species the range of size is so considerable that it is extremely difficult to separate large specimens of *S. tetracanthum*, and immature intestinal *S equinum* from the newly described species: indeed, short of absolute dissection and microscopical examination, I believe it to be impossible to do so. As a good naked-eye method of distinguishing between *S. robustum* and immature *S. equinum*, I may mention that the latter are usually much darker in colour, the small development of the generative organs permitting the blood filling the intestinal canal to be seen more easily through the skin than is the case with the mature *S. robustum* of the same size, where the intestinal canal forms but a very small proportion of the bulk of the body.

It is doubtless owing to its close external resemblance to the two species so commonly associated with it that it has not hitherto been recognised as a distinct species; and I shall not be surprised to hear that, now that attention has been directed to the point, it will sooner or later be found that its distribution is by no means confined to India.

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Surgeon, Indian Medical Service.

SANAWAR:
The 21st November 1891.

Explanation of Plate.

The three sclerostomes found in the equine large intestine.

I.—*Sclerostomum robustum* sp. n. Figs. 1—3.

FIG. 1. Female and male specimens, natural size.
" 1a. Lines showing length of above.
" 2. A pair in cephala × 6 diams.
" 3. Drawing of a preparation formed by splitting the anterior extremity of the worm × 70 diams.—
t. Circlet of tubercles surrounding the mouth.
c. Coronet of chitinous denticles forming a triphine, like that of *S. equinum*.
t, *p*. The four tactile papillæ.
y. Circlet of fimbriæ surrounding the upper limit of the oral cup.
o. The three large buccal teeth.
p. Pharynx.
" 4. Bursa copulatrix of male spread out, × 30 diams.
" 5. Ovum from uterus × 440 diameters. This figure is doubtless unnecessarily magnified, but is so represented for purposes of comparison with other ova delineated in this series.

II.—*Sclerostomum tetracanthum* Dies. (Figs. 6—11).

FIG. 6. Two lines representing the length of female and male specimens.
" 7. Head showing the four spines × 170 diams.
" 8. One-half of a split preparation of the anterior extremity of the body × 440 diams.—
s.s. The four labial spines.
y. Circlet of fimbriæ surrounding upper limit of oral cup.
b. Schneider's circlet of denticles.
o_1. & o_2. Anterior and posterior circlet of œsophageal denticles.
p. Pharynx.
FIGS. 9 & 10. Two specimens of male bursa copulatrix showing variability of outline × 70 diams. *g*. unicellular gland.
FIG. 11. Ovum from uterus × 440 diams.

III.—*Sclerostomum equinum* (Rud.) (Figs. 12—15).

FIG. 12. Lines representing the length of female and male of mature, or intestinal stage.
" 13. Head × 70 diams. from a specimen taken from a verminous aneurism from a mule.
" 14. Split preparation of anterior extremity of the same × 70 diams.—
t External circlet of trephine denticles.
y. Circlet of fimbriæ guarding opening of oral cup.
t, *p*. The six tactile papillæ.
s. The great external spine.
o. The great bidendate buccal tooth.
o_2. The circlet of pharyngeal denticles.
" 15. Male bursa copulatrix × 30 diams.

Explanation of Plate.

The three sclerostomes found in the equine large intestine.

I.—*Sclerostomum robustum* sp. n. Figs. 1—5.

FIG. 1. Female and male specimens, natural size.

,, 1*a*. Lines showing length of above.

,, 2. A pair *in copula* × 6 diams.

,, 3. Drawing of a preparation formed by splitting the anterior extremity of the worm × 70 diams.—

t. Circlet of tubercles surrounding the mouth.

c. Coronet of chitinous denticles forming a triphine, like that of *S. equinum*.

t, p. The four tactile papillæ.

f. Circlet of fimbriæ surrounding the upper limit of the oral cup.

o. The three large buccal teeth.

p. Pharynx.

,, 4. Bursa copulatrix of male spread out, × 30 diams.

,, 5. Ovum from uterus × 440 diameters. This figure is doubtless unnecessarily magnified, but is so represented for purposes of comparison with other ova delineated in this series.

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FIG. 6. Two lines representing the length of female and male specimens.

,, 7. Head showing the four spines × 170 diams.

,, 8. One-half of a split preparation of the anterior extremity of the body × 440 diams.—

s.s. The four labial spines.

f. Circlet of fimbriæ surrounding upper limit of oral cup.

b. Schneider's circlet of denticles.

o^1. & o^2. Anterior and posterior circlet of œsophageal denticles.

p. Pharynx.

FIGS. 9 & 10. Two specimens of male bursa copulatrix showing variability of outline × 70 diams. *g*. unicellular gland.

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t External circlet of trephine denticles.

f. Circlet of fimbriæ guarding opening of oral cup.

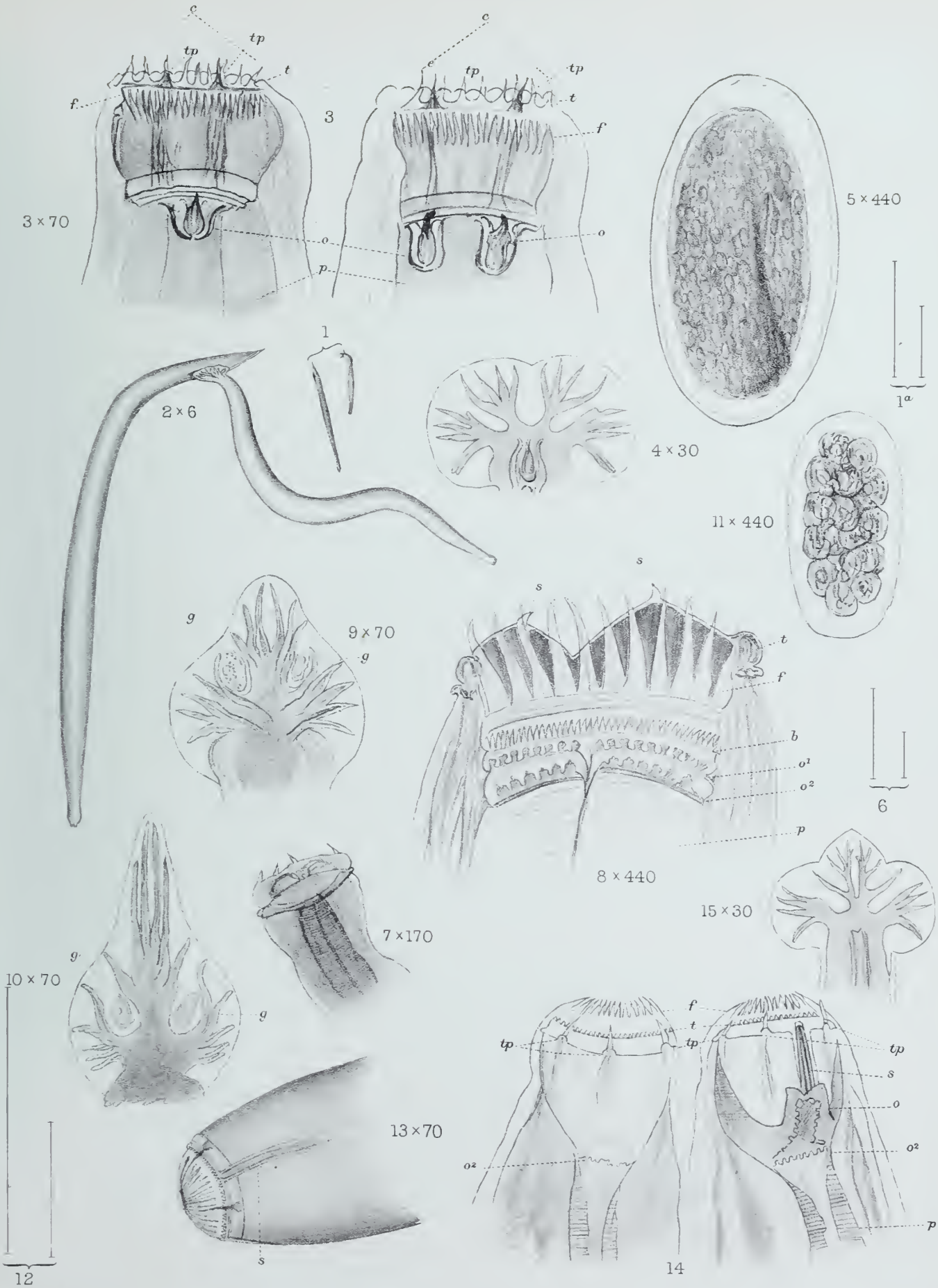
t.p. The six tactile papillæ.

s. The great external spine.

o. The great bidendate buccal tooth.

o^2. The circlet of pharyngeal denticles.

,, 15. Male bursa copulatrix × 30 diams.



Reg. No 698. San., I.—Mar. 92.—301.

Litho., S. I. O., Calcutta.

On nodular disease of the intestine in Sheep.

BY

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INDIAN MEDICAL SERVICE.

IT is an unfortunate fact that the rearing or keeping of sheep is next-door to impossible, either in Assam or Burma.

In both these localities mutton is a sort of exotic luxury, obtained at much expense by importation from India.

The supply of Rangoon, for example, is regularly brought over in the weekly B. I. boats, and, in Assam the butchers march sheep up from Bengal in comparatively small batches, and dispose of them as quickly as possible. Naturally, owing to the animals being slaughtered immediately after so severe a march, good bazar mutton is practically unobtainable; and hence, wherever the European population is sufficiently numerous, "mutton clubs" are formed, which import sheep, and fatten them up as rapidly as may be, for the table.

Not unfrequently, however, these co-operations fail owing to large losses of their sheep.

It is needless almost to say that these losses are always ascribed to that favourite scapegoat for hazy sanitarians—*climate*; though how or why the climate of the Indo-Chinese peninsula should be particularly prejudicial to sheep I cannot remember any one attempting to explain.

The explanation I have now to offer refers the mortality ultimately, it is true, to climatic conditions; but it has the advantage of explaining how and why the climate acts prejudicially, and therefore of showing us in what direction we may best take preventive measures.

The fact is that the prolonged dampness of these climates is peculiarly favourable to the welfare of the free stages of nematode parasites, many of which are particularly fatal to cattle in general, and to sheep and solidungulates in particular. Of Burma I can say but little, and can only judge from a few reports from others, and from the probability afforded by similar climatic conditions; but, with regard to Assam, I can, from personal observation, answer for the fact that its climate forms a sort of paradise for parasites.

I examined, in connection with my investigation of Kala-azar, the carcases of several species of animals; and not only every species, but every individual, was found to harbour more or fewer species of entozoa, many being perfect miniature

helminthological museums. The leading fact brought out by my investigation of *Dochmius duodenalis*[1] in the human subject, of *Sclerostomum tetracanthum* in horses, and of the present investigation, is that the persistently endemic presence of the diseases to which these parasites give rise is owing to the circumstance that all these species are capable of living and breeding freely, indifferently as entozoa or as free living animals; and, further, that these free-stage nematodes possess wonderful powers of resistance to adverse conditions. Their great enemy is drought. It is true that they are capable of passively resisting it; but they can only oppose it by retiring to a sort of condition of suspended vitality, and cannot flourish and multiply as they do when favoured by damp surroundings.

The free-stage "rhabditis" of *Dochmius duodenalis* cannot, for example, resist prolonged exposure to the full heat of the sun, but they can remain dried up, but still alive, in moderate shade for an indefinite period; and it is probable that the same is the case with the free-stage generations of allied species, though I have no direct observations to adduce in their case as I have in the case of the *Dochmius* rhabditis.

Periods of drought are, however, periods of suspended vitality, if not of infectiveness. The chances of infection for the host depend entirely on the opportunities of multiplication enjoyed by the free generations; and, in the case of those of *Sclerostomum tetracanthum*, recently described, and of those of *Œsophagostomum columbianum*, on the consideration of which we are about to enter, the opportunities of multiplication may be said to depend entirely upon the character of the weather; as not only are they unable to breed except in damp surroundings, but their supply of suitable food depends on the same conditions.

Few climates can offer these conditions in greater perfection than that of Assam. The protracted period of the rains, lasting practically from March to November, is immediately succeeded by a cold season characterized by heavy fogs, which, commencing long before dawn, last often well on towards noon, and which so thoroughly saturate the soil and herbage that a stranger would imagine that a heavy shower had fallen during the night. Practically February and a portion of March are the only months in which, ordinarily, the soil has a chance of drying, and this period is quite insufficient to do much harm to the free-generation nematodes, save in situations where the soil is absolutely open and bare, which, in such a climate, are naturally few and far between. Given then the presence, in such a climate, of a parasite inimical to the life or well-being of any animal, and it may be taken as certain that that animal will be unable to thrive there.

Thus, though my deductions, in the present case, are founded on an isolated observation, I feel convinced that further investigation will show that the reason of the difficulty of sheep-keeping in Assam may be considered as solved.

The disease is moreover to be met with, to a less virulent extent, in the Punjab.

[1] Report of an investigation into the causes of the diseases known in Assam as Kala-azar and Beri-Beri.—Assam Secretariat Press, 1890.

Shillong is as badly off for mutton as other parts of Assam, the bazar supply being often uncertain, and uniformly poor. Under these circumstances, a mutton club of some sort is a necessity, and during the season of 1890 a sort of Proprietary Club for the purpose was started by Mr. Fenton, the enterprising Manager of the Shillong Hotel; the "Club" element being, however, represented only by a number of residents undertaking to take the mutton, while he incurred all risks.

Grazing being abundant and excellent, he got up from Bengal a considerable number, and, by a liberal supply of grain, succeeded for a while in supplying excellent mutton.

After about six weeks, however, the quality began to fall off, till, in another month, he was obliged to suspend his supply, no sheep remaining in a fit condition to kill.

Then the sheep began to die off, not in numbers at a time, but one by one.

The animals did not appear to be in any suffering, but were feeble and dejected looking, though they eat greedily till nearly the end. The supply of grass was unlimited in quantity and good in quality, and, in addition to this, they were given a liberal ration of grain. They were well housed, at night, in a large shed, the floor of which was raised on poles several feet above the ground. Their water-supply was above suspicion. Yet, in spite of such exceptionally favourable conditions, the leading symptom of the epizootic that was frustrating all Mr. Fenton's efforts to supply us with good mutton was a slow and progressive wasting. In advanced cases an examination of the mucous membranes of the conjunction and mouth showed them to be singularly bloodless, though, perhaps, hardly so markedly so as in the case of the horses affected with sclerostomiasis described in the preceding paper. Death was usually ushered in by scouring; but this symptom was characteristic only of the end of the case, and was by no means invariably present.

Sometimes the wasted animal would be only "off its feed" for a day or two, and then be found dead in the morning.

My attention having been so forcibly drawn to helminthiases as a cause of mortality among men and mules, I naturally suspected that such similar symptoms among sheep might be due to a similar cause, and accordingly I proceeded to examine the droppings of the affected flock. The specimens were taken at random from the floor of the hut, and, without exception, every nodule was found to contain immense numbers of characteristic strongyle ova.

It was clear that more than one species was present; but the dominant species was one which produced somewhat oblong ova, intermediate in size between those of *S. tetracanthum* and *D. duodenalis*, and measuring, in fact, about 0·082 mm. in length by 0·047 mm. in width.

From nodules selected as containing only the ova of what I may call the dominant parasite, I instituted some cultivations. These were conducted by

simply breaking down and slightly damping the nodules, placed in a crystalizing glass, and covered to prevent evaporation. I succeeded in following their development under these conditions further than I was able to in the case of *Sclerostomum tetracanthum*, as they had advanced well on to the sexually mature condition, and had developed the peculiar styliform mouth armature before the conditions became too unfavourable for further development. It would be a mere waste of expensive lithography to figure these, as they are almost identical in appearance with the free stage of *S. tetracanthum* already described and figured, and differ only in some minute details, which pressure of work at that time prevented me from minutely noting. There can, however, be no practical doubt that, in order to attain complete sexual maturity, they require to gain access to the forage plants which supply them alike with food suitable for their free-stage life, and the opportunity of infecting new hosts for their parasitic generations.

Under these circumstances I urged Mr. Fenton to send me the carcases of some of the dead sheep for examination; but, one way and another, it was not until July that I obtained the opportunity I required.

I extract from my diary a brief account of the examination.

Carcase, poor; flesh, watery; mucosa, pale. Lungs, some congestion at bases (mainly hypostatic), freely crepitant throughout. In bronchi I found four specimens of *Strongylus filuria*, Rud. (a number inadequate to do any particular harm). Heart, liver and spleen healthy. Intestinal canal—stomach The rumen contained large numbers of *Amphistomum conicum*, Rud. In addition to these, a few specimens were found of a filiform nematode about 9 c. m. long, which appears new to science. (A description is appended.) Only female specimens were found; but some were present in all divisions of the stomach, except the reticulum. Small intestine—dotted throughout its length with small nodular tumours, varying in size from a pin's head to that of a large pea. The larger tumours are full of greenish caseous matter, and mostly contain no worms; the smaller ones contain each a minute, sexually immature nematode, with cup-shaped mouth cavity.

Throughout the entire length of the small intestine, becoming more plentiful in descending, were found considerable numbers of a small strongyle. (This appears to be hitherto undescribed, and a description is appended under the name of *S. colubriformis*.) Large intestine dotted throughout its length with nodular tumours, like those seen in the small intestine. In addition were found free, large numbers of another strongyle, near *S. tetracanthum*, which I could not then identify, but which, without doubt, was the adult stage of the tumour-producing immature worms, and the efficient cause of the death of this sheep, and doubtless of the epizootic generally. Many thousands must have been present; but their numbers still could not approach those in which I had found *S. tetracanthum* in equines.

The scanty literature I possessed contained no reference to it, and I was just going to write to my long-suffering friends at the Indian Museum, to beg them to search out for me any references there might be to new ovine nematodes that might have been described, with the view of describing it under the name of *S. orientale*, should it prove to be new, when I met with, in the current "Journal of the Royal Microscopical Society," a notice of a work by Dr. Curtice, of Washington, United States of America, monographing the animal parasites of sheep, and determined to hold my hand till I could obtain a copy. The work is published by the United States Bureau of Agriculture, and I had some difficulty in getting one. It is as well, however, that I delayed, as I found my worm described in it as a new species, which would have had a priority of several months to any description I might have publishe d.

Nodular disease of the intestine had been, it seems, known as a widely-spread and fatal disease among sheep in America for many years, but investigators had wasted their energies in fruitless searches for the tubercle bacillus; and it was reserved for Dr. Curtice to demonstrate the true cause of the disease, an achievement which he looks upon as the most important outcome of a long and exhaustive investigation into the ovine helminthology of North America.

His descriptions and observations generally coincide exactly with my own in every particular, except that he is unaware of the existence of a free stage to the worm, and assumes that sheep are directly infected by swallowing the ova. My measurements of the ova give a somewhat smaller figure than his; but I notice that this is the case also with the ova of other parasites which we have both measured; so that it is probably due, not to any difference in the material observed, but to some error in the methods employed by one or the other of us. My own measurements were taken by comparing the size of a camera lucida drawing of the ova with that of a micrometer scale, the two drawings being made under absolutely unchanged conditions, the micrometer being merely substituted for the slide, and its divisions drawn beside the outline of the preparations. The accuracy of the micrometer employed was also tested by comparing a drawing of it under a low power with those of an actual full-sized engineer's scale; so that I see little room for error in my determination, and am inclined to prefer them to those of Dr. Curtice, who may have employed merely the eye-piece micrometer, an instrument which is apt to give only approximate results, small differences in the focussing of the eye piece scale leading to perceptibly discrepant results.

The description below is taken from Curtice, but with some minor additions. *Œsophagostoma columbianum*, Curtice.—*Description.*—Male, 12 to 15 mm. long; female 14-18 mm. (Curtice.) (I have a female specimen measuring 22·86 mm. or 0·9″). Body, of nearly uniform diameter throughout, tapering abruptly at head and tail. Greatest diameter, in both sexes about middle of body-length;

[1] United States Department of Agriculture, Bureau of Animal Industry:—"The Animal Parasites of Sheep," by Cooper Curtice, P.V.S., M D.—Washington, Government Printing Office, 1890.

0·56mm. in female ; 0·44mm. in male. Head usually bent down, often into the form of a hook. Papillæ six, of which two are dorsal, two ventral, and two lateral ; the latter are more obtuse, and are the openings of the lateral canals. Mouth, terminal, provided with a chitinous armature, consisting of an annular ring, supporting two systems of 24 teeth each (Curtice). My own observations lead me to believe that the armature is more complex than this, and that there are three rows of differently-shaped "teeth." The complexity of the object, however, renders its resolution, even with high powers, a very difficult matter, especially as the images of the various rows of teeth are further confused by a radiate ribbing of the chitinous lips, so placed that each rib is opposite a set of "teeth." The innermost row have a very characteristic bidentate form, while the second are long and slender, and have the form of a linear-lanceolate leaf, with the proximal portions of the margins rolled in towards the midrib.

These fimbriæ, by their convergence, form a sieve, exactly similar to that described in the equine sclerostomes, and, external to them, and corresponding in position to the trephine circlets of *S. equinum* and *robustum*, I make out a circlet of short teeth, with semi-lunar margins. The circumference of the mouth is curiously ribbed, the ribs being equal in number and opposite to the tooth systems, and it is, I think, from confusing the image of this ribbing with the overlying triphine teeth that this circlet has been overlooked by Dr. Curtice in his description. Immediately beneath the ring supporting the bidentate teeth is the triradiate opening of the œsophagus, no chitinous buccal cup intervening, as is the case in the allied genus *Sclerostomum*. Neck, not inflated, but provided with a lapel or cuticular fold, on the ventral aspect, just in front of the ventral cleft ; the fold continues slightly on the dorsal aspect. Two lateral, narrow, membranous wings begin at this fold, and continue for one-fourth the length of the worm. The two lateral opposite papillæ are in these wings, at the level of the first third of the œsophagus. The pair of unicellular neck glands (lemniscus) unite into a common duct and empty at the ventral cleft, situate beneath the median fold. Male, about three-fourths the length of the female. Bursa can, with difficulty, be spread without tearing. It is slightly prolonged dorsally, but notched in the middle line so as to indicate a primarily bilobed arrangement ; ventral cleft shallow. Costæ symmetrical, the ventral slightly separated ; the dorsolateral forms with its fellow and the dorsal pair a group ; dorsal rib bifid ; the divisions widely separate at free ends. Spicula two ; subulate, bordered by a very narrow membrane ; the chitinous cylinder is apparently fenestrated. At either side of the genital aperture are two knobbed papillæ. Female, relatively stouter ; vulva just in front of anus, which is close to the mucronate tail ; usually covered by a brown crust, consisting of ova glued together by mucus ; reproductive organs in two symmetrical sets anteriorly directed, except a small portion of one which loops backwards in front of the anus. Uteri caudally placed ; can be followed to ovaries, which continue forwards to œsophagus, below which they are reflected to form a loop, reaching

nearly to the vulva to form yet another loop. Ova laid as a gastrula ; length, 0·082 by 0·047 mm. (0·09 by 0·05 mm., Curtice).

Life-History.—The similarity between *Œsophagostoma columbianum* and *Sclerostomum tetracanthum* in anatomy and life-history, in all points that are certainly known for both is so close that there can be no practical doubt that the two histories are in all points identical.

The ova of the present species hatch out the first or second day after the deposition of the dung. Shortly after their escape from the egg they can be found in the moistened dung as immature rhabdites 0·5 mm. in length by 0·03 mm. at their greatest thickness. At this stage the digestive organs alone are developed. The œsophagus is provided with two bulbs, the upper of which, however, is very indistinct, while the lower is thick and globular, and provided with a distinct chitinous armature. The tail is short, and rather abruptly tapered, and has no long lash, such as characterizes the rhabditis of *S. tetracanthum.*

When first observed, I was closing up my laboratory work at Shillong and had no time to devote to experiments which would probably last through several months. Now that I have a fresh supply of material, the temperature of the air appears to be inimical to their progress, as but few have hatched out. I hope, however, to be able to follow out the subject more closely during the favourable period of the next rains. I have, however, followed them until they were far on to the mature rhabditis stage, the generative organs being already well outlined, though not as yet sexually distinct, and the mouth having acquired the peculiar hollow-style armature which I have described and figured from *S. tetracanthum.* After leaving the dung, like the rhabditis of that species, they doubtless climb on to succulent forage plants, on the juices of which they feed by means of their sharp, hollow, protrusible style. Here they attain sexual maturity and multiply for more or fewer generations. If now some of these rhabditis progeny be swallowed by sheep along with their food, their next step is to bore into the intestinal submucosa and there to encyst themselves. Thus situated, with an abundance of nourishment all round them, they grow rapidly to a size many times exceeding that of the free generations, and, when ripe to attain sexual maturity, they bore their way back into the intestine, and, by a series of moults, gradually acquire their peculiar mouth armature, become sexually mature and lay, with the dejecta of their host, the immense number of eggs which are destined to start the cycle of life afresh.

Dr. Curtice states that the worms moult at least three times during its (parasitic stage) development, but on this point my observations have been too desultory to be of value.

He indicates also his belief that the worms do not always encyst, but may undergo all their changes within the intestine, basing his opinion on the fact that large numbers of free adults were found in a lamb only a few weeks old, in the intestine of which only a few small tumours could be found. It is, of course,

quite possible that this may be the case; but it appears *a priori* improbable, and I should rather be inclined to attribute the absence of large tumours to their having been re-absorbed, a process which would naturally take place with exceptional rapidity in so young an animal.

An examination of sundry specimens of grass, not known to be infected, has led me to the suspicion that many of the free living nematodes which may be found in such situations and which have hitherto been regarded as distinct species, may be but free-stage examples of certain parasites. In the determination of this point, I believe that a comparison of the ova of mature specimens will be of the greatest value, as in the two examples I have hitherto investigated the one point of resemblance between the free and parasitic generations was the absolute anatomical identity of their ova. It need not, of course, follow that because the normal method of infection is, by the ingestion of embryos, indirectly descended from parasites, that the swallowing of direct descendants would be unattended with risk. Indeed, the more I consider the matter the more I am led to the conclusion that it is a matter of absolute indifference to the just hatched embryo whether it finds itself in free or in parasitic surroundings, or whether it be the direct progeny of the parasitic or of the free stage. The ova probably, however, cannot hatch out in the absence of oxygen as, for example, would be the case if swallowed. The only difference would be that, by affording these different surroundings, two brother emrbyos might be made to develop respectively into the widely different free and parasitic mature adults. The actual demonstration of this by experiment would be fraught with difficulties, and could only be accomplished on an experimental farm. One would have, to begin with, to raise some stock absolutely free from parasites, and widely distributed as these now are, one would have to take lambs as soon they were dropped, and to artificially feed them, throughout their life, with milk, and afterwards with fodder which had been raised to a sufficient heat to destroy all parasitic life. That this is no exaggeration is shown by the fact that I have never, in India, thoroughly examined the carcase of any mammal without finding entozoa.

It is obvious that this power of being able to live and breed indifferently, either as free nematodes or as parasites, adds immensely to the power of the species to perpetuate itself.

Pathology.—Once one's attention has been directed to the matter, it is impossible to mistake the appearances presented by this disease for any other condition, except perhaps tubercular disease of the intestine, which is, however, I believe, rare or unknown in sheep. The larger tumours form coarse, naked-eye lesions, which can be seen and felt as hard opaque nodules, even in the unopened intestine, but can best be studied by slitting it open, and, after thoroughly washing it, holding it up to the light, when even the smallest tumours stand out as opaque dots. To make matters certain, stretch a piece of intestine containing a medium-sized tumour over the tip of the finger and snip out the tumour with a pair of scissors curved on the flat.

Place the morsel of tissue in a shallow glass tray of water under a simple microscope. Then slit the tumour with a fine knife under water, and press out its contents with the flat of the blade. By a little teazing of the cheesy mass, it is then quite easy to separate the little worm, which is quite large enough to be easily visible under a power of eight or ten diameters.

The tumours will be found scattered over the whole length of the intestine, but become more numerous as one descends, and are most plentiful of all in the cœcum and upper part of the colon, ceasing to be found about that part of the large intestine where the nodular dung commences to be formed. Below this I have not found them, and I have not as yet positively demonstrated their presence in the stomach, though, from some appearances met with in the absomum of one carcase that I have examined, I am inclined to believe that they will ultimately be found to occasionally encyst themselves in that organ.

The little worms are enclosed in a sort of cyst, which is especially easily demonstrable in the smaller tumours, and, in addition, there is a sort of second cyst to all, formed by inflammatory infiltration of the surrounding tissues. In the larger tumours the worm itself and its proper cyst forms but a very small proportion of the contents, by far the greater bulk being made up of thick cheesy material, the greenish colour of which clearly shows it to consist of altered blood clot. In the very largest it will nearly always be found that the worm has escaped, and yet another category will be found, of medium size, in which the worm has also escaped, but which differ from worm-holding tumours of the same size by their dark, brown colour, and shotty feel. These are tumours in the course of absorption, and, in some, the addition of dilute acid will demonstrate the fact that their contents have undergone calification. The natural course of events lies in the direction of absorption of th contents of the tumour, or their reduction to calcareous nodules and recovery; but when the health of the host is too far undermined to admit of this, or when, perhaps, there is some special septic infection of the puncture made by the worm, the tumour will break down, and leave a small, circular, undercut ulcer. This was the case in nearly all the larger tumours found in the first carcase examined at Shillong, and, in spite of their individually small size, their large numbers were quite sufficient to account for the dysenteric symptoms that ushered in the animal's death.

The worm found within the tumours is sexually immature, and differs entirely in appearance from the adult, the mouth parts never attaining adult characters, as is done by *S. tetracanthum*. In the larger ones, about the middle of the body, may be made out a spindle-shaped mass of protoplasm, which is the rudiment of the generative gland. The description of them, given below, is from Curtice:—

"From 0·23 mm. upwards. The largest found in tumours were 4 mm. long; the smallest male, found in intestine, being 7 mm. long. The smallest embryos were without digestive apparatus?? The largest possessed an intestine, unicellular glands (lemniscus?

G. M. G.), and a well-formed, chitinous, cup-shaped oral aperture; also six cephalic papillæ, and at the neck two papillæ, and a well defined fold."

I am inclined to believe that the observation as to the absence of digestive apparatus is erroneous. I have watched many embryos of this species as they issued from the egg, and have always been able to make out an already well-developed digestive tract, with a double bulbar apparatus, even in those that had but just wriggled out of the egg-shell. One often sees similar notices with regard to other nematodes, and I have met with specimens where, at first sight, I could make out no digestive organs, but by careful examination and the use of suitable re-agents have always been able to prove my first impression to be wrong. I believe most of these false observations arise from the unchecked examination of balsam and glycerine mounted specimens, media which quite obliterate fine details for thick specimens. They are best examined in water, and the addition of a little suspended carmine to the water containing living specimens will often show up the intestine. Failing this, the addition of a small proportion of alcohol may be tried, or tear up a specimen with needles and stain with borax carmine or picrocarmine. Without previous slitting or tearing, it is useless to attempt to stain, as the impermeable chitinous cuticle entirely prevents the stain from reaching the organs which it is desired to differentiate.

If the newly-hatched embryos have well developed digestive organs, it is *a fortiori*, highly improbable that the much older encysted worms should have these organs undeveloped, and I certainly have not met with any such.

His minimum measurement too appears to me curiously small. Embryos fresh from the egg are larger than this.

The adult worms are found exclusively in the large intestine, and, so far as I have seen, their favourite residence is some distance along the colon, but few, as a rule, being found in the cœcum. The only ovine parasite they are likely to be mistaken for is *Dochmius hypostomus* Diesing, which, being about the same size, and having the same habitat, is easily confused with it. *D. hypostomus*, however, averages larger, in all dimensions, and may be further distinguished by the more distinctly globular form of the head, which forms quite a knob at the end of its body, and the form of the male bursa, which has an elongated, instead of a transversely oval, outline.

I am doubtful whether our species has the habit of blood-sucking. I have not yet met with them actually hanging on to the mucous membrane; but this may be owing to my never having examined a warm carcase. However that may be, it may be considered certain that the harm they do as adults is small compared with the mischief effected during their stage of encystment.

From the fact that the number of free adults found is generally small in comparison with that of the tumours, it is probable that the period of their stay within the intestine is comparatively short, and that they rapidly discharge their generative products, and are then extruded with the dung.

The harm done by the encysted worms, on the other hand, must be ex-

tremely grave. The lesions produced are practically identical with those of intestinal tuberculosis, and, from our experience of human pathology, we well know how dire a disease is that.

It must be remembered that the worm makes its puncture from a cavity full of various septic germs, and hence that the wound so produced must always be a septic one. Witness the foul character of all suppurations that take place in the neighbourhood of the digestive tract. Further, the resorption of the cheesy matter is certain to be attended with further sepsis, and recovery can only be gained by its absorption.

In this, as in most other helminthiases, it must be remembered that the element of number is most important. Short of some accidental septic infection of the punctures by some poison of exceptional virulence, it is inconceivable that any perceptible harm should be caused by a dozen or so of encysted worms; but, on the other hand, it is equally impossible to imagine that any considerable number can be present without gravely affecting the health of the host; or that, beyond a certain limit of number, determined by individual resisting power, the continuation of its life should be possible.

The sheep I examined at Shillong, *e. g.*, had passed that limit, while those I have examined at Sanawar were carcases taken at random from the ration stand, and were not affected to a fatal extent.

The ration mutton here is extremely poor, and it is by no means easy to obtain really prime meat, even by paying a high price for so-called gram-fed mutton. In the carcases, moreover, that I have examined, the poorness of the carcase was distinctly proportional to the severity of the infection, while the full maws of the animals further showed that this poorness was not to be accounted for by scantiness of food supply; and it is to be noted that the examinations were made just after the end of the rains, when the grazing had been for months plentiful. Now, as it is impossible to believe that such grave lesions can exist without seriously affecting the health of the animals, I think it may be taken as proved that the poorness of the meat is mainly caused by the parasite under discussion. At the same time it must be remembered that other parasites help in producing this wasted condition, and, in some cases, have more to say in the causation of the leanness of the meet supply than *Œsophagostoma columbianum*. A very large proportion of the carcases, *e.g.*, show numbers of cysts (*Tænia echinococus*), the liver and lungs being often absolutely riddled with them. In one case two or three minute embryos could be found in almost every section of the viscera, the sections being not more than $\frac{1}{4}$th inch square and less than $\frac{1}{1000}$ inch thick.

Ruminants appear to suffer much less injury than man from harbouring this parasite; but when matters go to such an extent, health is clearly impossible to the host.

Intestinal (adult) tapeworms are also almost universally present. *Tænia*

expansa in some, and another smaller tape worm, which I have not yet been able to identify, in nearly every case; and these too no doubt help to swell the mischief. At the same time, making all allowances for the influence of these parasites, it is, I am convinced, to the ravages of *Œsophagostoma columbianum* that the poorness of our supply of mutton is mainly due.

It is remarkable that, out of over a hundred animals examined, I have never in the Punjab met with either of the two lung strongyles which are so destructive to sheep in some parts of the world.

Diagnosis.—For the stock-keeper the only symptom will be wasting, followed perhaps by diarrhœa, often of a dysenteric character. The existence of such symptoms in animals inhabiting any region known to be infected by this parasite should at once arouse suspicion, and the diagnosis can easily be confirmed by slaughtering one of the suspected animals and examining the intestines for nodules. The veterinary expert may make an equally sure diagnosis by merely examining the dung under the microscope. Owing to their large size the ova can be seen with a low power in dung mixed with water in a shallow glass tray. In order to make sure, the ova must be measured, and the best plan will be to arrange the camera lucida so that it gives 440 diameters, and to compare the outline with the drawing given in the plate.

Treatment is, from the nature of the case, almost hopeless. No vermifuge can be expected to exercise any effect on the encysted worms, and it is by these that the main part of the mischief is effected.

The adult worms could probably be expelled by means of thymol; but it may be doubted if they do sufficient harm to make it worth while to attempt their expulsion. Apart from which, the value of a sheep in bad condition would, in India, be but little in excess of the cost of the dose.

Prevention.—In this direction too the outlook is not hopeful. It would not pay to cut grass for sheep, and, as it is impossible to prevent their depositing their droppings on their grazing ground, the only possible method of prevention lies in the detection and prompt slaughtering of all infected animals; but, owing to the ability of the species to exist continuously as a free nematode, this would have to be supplemented with periodical burning of grass on pastures, and would have to be persisted in for a long time before any great results could be expected.

The meat, such as it is, is in no way rendered unsuitable for food, and, as the sheep cannot be expected to improve while harbouring this parasite, the sooner they are slaughtered the better for the pocket of the sheep-owner.

As anything like systematic inspection of flocks, however, would be difficult, even in the most highly civilized of countries, and is entirely out of the question under the conditions of Indian agriculture, I think the most that can be done is to encourage grass-burning before the rains. Such a procedure would inflict a severe check on the mutiplication of the free stage of the species, and would at least give the lambs a fair start on uninfected pasture.

Curtice suggests stall-feeding, and this would, no doubt, be useful, provided

the fodder be obtained from localities over which sheep are not allowed to range, without which precaution it would be obviously useless. Where expense and trouble is not so great an object, as in the case of mutton clubs, this expedient, combined with disinfection of the fodder by heat, might be tried, and would be specially worthy of trial in localities like Assam, where mutton is a nearly unobtainable luxury, as I believe, mainly owing to this disease.

Conclusion.—It will, I think, be admitted that the facts that have been adduced in these two papers are sufficient to show that the damage to live stock wrought by parasites is much greater than has hitherto been suspected, and that many apparently inexplicable epizootics may be due to their ravages.

There is a strong tendency, even among professional men, to ignore the power of mischief possessed by intestinal parasites, and to treat as "only worms" organisms which live on the blood of their victims, and riddle their tissues to a sieve. While it is sufficient to discover a bacterium visible only under the best oil immersion lenses for the majority to be convinced that we have there the *causa causans* of the disease with which it may be associated, it is quite otherwise with animal parasites large enough to appeal to the naked eye, armed though they be with fangs and borers formidable enough to conduct phlebotomy, artenotomy, and other disagreeable surgical procedures to any extent that their insatiable appetites may suggest.

Let it not be imagined that the writer undervalues the morbific powers of the bacteria; but in medicine, as in other things, the influence of fashion comes in, and we live, just at present, in a bacteriological era in which it is hard to obtain a hearing for any other source of disease.

We want no more than the now classical example of anthrax to show us that animals, as well as men, fall victims to diseases caused by bacterial poisons, but all cattle disease is not anthrax, nor does it follow that because we may find micro-organisms in association with disease that they stand to each other in the relation of cause and effect. It is a characterstic of helminthiases that they may be combated by the most rudimentary sanitary measures; and hence it is that there are but few parts of the world left where the entozoa constitute any serious danger to man. But it is quite otherwise with animals, whose natural habit of indiscriminately fouling the soil defeat the most laborious efforts of man in the case of domestic species to keep them in cleanly condition. Hence, even in Europe, the losses from parasitic disease among domestic animals are still serious; and I am convinced that for cattle in India helminthological investigation is far more urgently needed than bacteriological research.

G. M. GILES, M.B., F.R.C.S.,
Surgeon, Indian Medical Service.

SANAWAR:
The 26th November, 1891.

Post scriptum.—While the above has been in the press, I have made the further discovery that encysted Œsophagostoma may be found also in by far the larger proportion of carcases of oxen that I have been examining. The species, however, evidently does not find itself at home in bovines, for the tumours remain for the most part small, comparatively few going on to the caseous stage, though the total number present has been very large, in one or two cases. The trichonemes, after escaping from encystment, however seem quite incapable of developing within the sloppy surroundings of the bovine colon. At any rate, the most careful search has failed to bring to light a single adult or even maturing specimen. I hope to deal more fully with this point at some future opportunity.

G. M. GILES, M.B., F.R.C.S.,
Surgeon, Indian Medical Service.

SANAWAR:
The 30th December 1891.

Explanation of Plate.

A. Fig. 1. Œsophagostoma columbianum, Curtice.

Head × 280 diameters. The two padilla which serve as openings of the lateral canals are seen on either side. Of the other four tubercles, only one is shown, to avoid confusing the outlines of the armature

" 2. Split preparation of the head of the same × 280 diameters showing, first, a ring of plates with semilunar ends, next the circlet of fimbriæ, and lastly, the circlet of bidentate teeth, below which is the wide œsophagus.

" 3. Bursa of male Œsophagostoma partially spread × 70 diameters.

" 4. Ovum of Œsophagostoma × 440 diameters taken from the clot adhering to the vulva.

" 5. Trichonema stage of Œsophagostoma from tumour of intestine of sheep.

" 6. A portion of the large intestine of a sheep affected with nodular disease of the intestine. Natural size.

B. Trichosomum serrucosum, sp. n.

" 7. Trichosomum serrucosum, ♀, natural size.

" 8. Head of the same × 28 diameters.

" 9. Caudal extremity of the same × 28 diameters—

a—anus.

v—vulva.

u—uterus.

i—intestine.

" 10. Ovum of above, from uterus × 440 diameters.

Explanation of Plate.

A FIG. 1. *Œsophagostoma columbianum*, Curtice.
Head × 280 diameters. The two padillæ which serve as openings of the lateral canals are seen on either side. Of the other four tubercles, only one is shown, to avoid confusing the outlines of the armature.

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B. *Trichosomum verrucosum*, sp. n.

,, 7. *Trichosomum verrucosum*, ♀, natural size.

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,, 9. Caudal extremity of the same × 28 diameters—

a—anus.
v—vulva.
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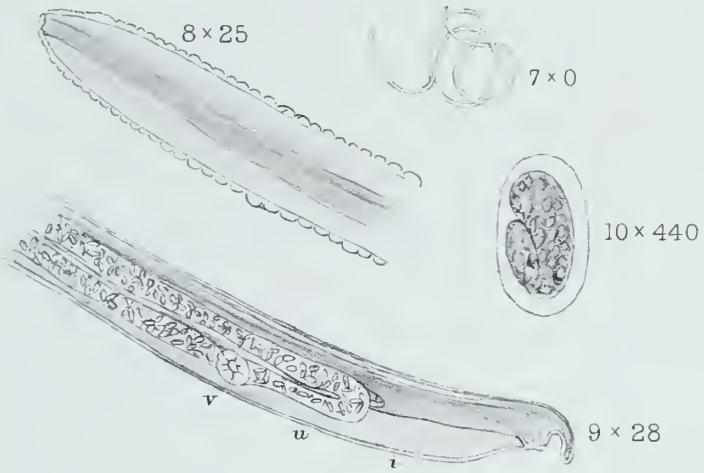
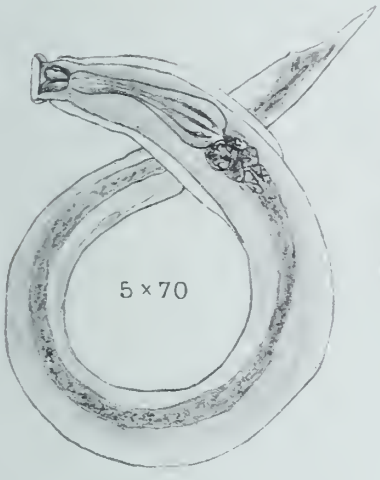
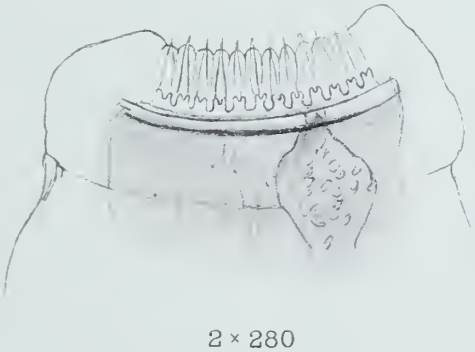
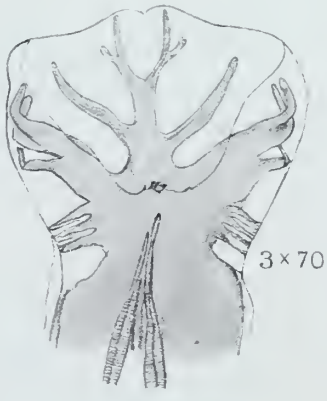
i—intestine.

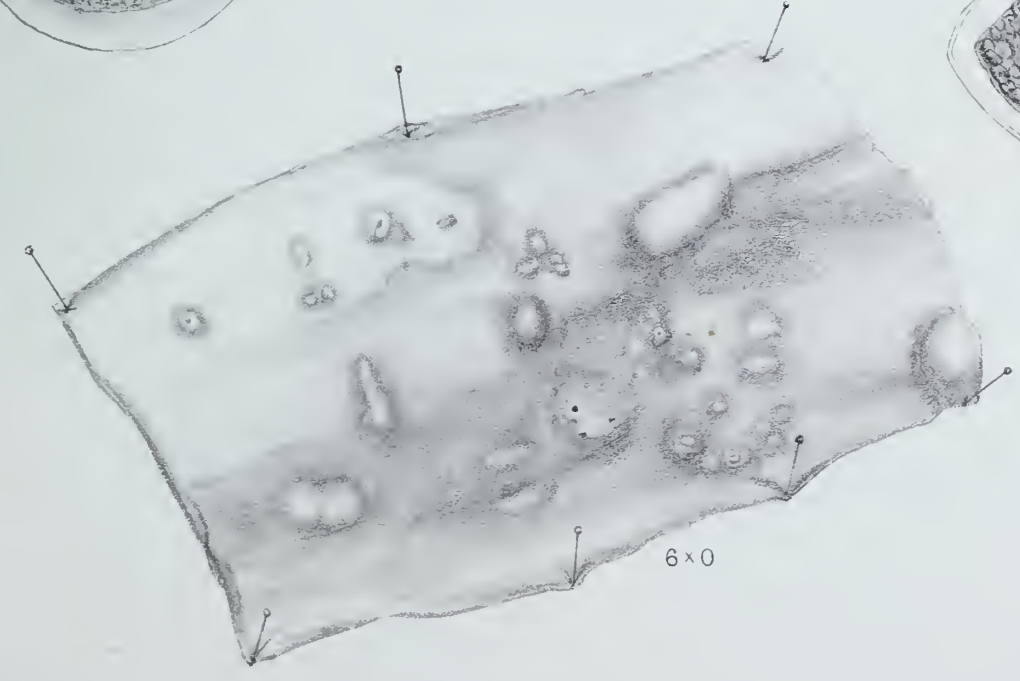
,, 10. Ovum of above, from uterus × 440 diameters.











Reg. No. 698, San., I.—Mar. 92.—301.

Litho., S[illegible]O Calcutta.

A description of two new nematode parasites found in sheep.

BY

SURGEON G. M. GILES, M.B., F.R.C.S.,

INDIAN MEDICAL SERVICE.

Strongylus colubriformis and ***Trichosomum verrucosum.*** } sp. n.

With a note on *S. ventricosus*, (Rud.?)

AS already noted in the preceding paper on nodular disease of the intestine, during that investigation, I met with two nematodes which appear to be new to science. It is probable that both are innocent of doing much harm, beyond abstracting a certain amount of nourishment; but it is nevertheless desirable that a sufficient description of them should be placed on record.

Strongylus colubriformis, sp. n.

Description.—Male nearly 6 mm. (0·2″) in length, 0·13 mm. in thickness. Female, about 8 mm. (0·3″) in length, about the same thickness.

Body dark coloured, the female usually straight, the male more usually contorted. Both sexes have the head extremely attenuated, and become progressively thicker as the caudal extremity is approached; but while in the male the thickest part is quite at the caudal extremity, the female is thickest opposite the vulva, which is placed one-fifth of the entire body's length from the mucronate extremity of the tail. Mouth, entire; quite unarmed. The female is provided with a pair of semi-ellipticalæ, situated opposite the neck, which is markedly constricted, giving her the outline of a cobra.

Bursa of male deeply bilobed, the dorsal cleft being almost as deep as the ventral, so that the organ looks like a mussel shell, placed transversely, and attached to the worm at the hinge. Ventral costa small; the lateral and ventro-lateral costæ stout, subequal, and forming a closely packed group; dorsal and dorso-lateral costæ small.

Ova (intra-uterine) elliptical, 0·09 mm. long by 0·046 mm. wide. A more advanced ovum, apparently mature, measured 0·11 mm.

This small species inhabits the small intestine, and is most numerous about the middle of its length. I have found it, both at Shillong and Sanawar, in every

carcase examined completely. It attaches itself to the mucous membrane in exactly the same manner as is done by the *Trichocephali*, the head tunnelling just below the epithelium for some little distance, while the tail hangs free. It is almost impossible to detect it in the primary examination of the intestine; requiring careful examination of the mucous membrane under the simple microscope.

The easiest way to find it, however, is to wash a certain length of intestine which has soaked for some hours in carbolized water, rubbing it well between the fingers and to examine the washings by transmitted light. From the numbers I have obtained by washing a comparatively small portion of intestine, I should say that they are often present in enormous numbers.

Its close resemblance, in all save size, to *S. contortus*, the common sheep maw-worm, cannot be overlooked. Dr. Curtice[1] gives an excellent description and plate of *S. contortus*, but neither figures nor describes the cervical alæ described by Diesing in his diagnosis of the species. It is, however, present in a large proportion of the specimens in my own collection, though it is seldom wide enough to merit Diesing's epithet of "semi-elliptical." Its presence, however, adds a new resemblance to *S. colubriformis*, the minute species at present under consideration, though I am by no means sure that it is uniformly present in that, even in females.

The determination of this point is rendered difficult by the fact that they are only visible when the worm is lying, so that they project; when half turned round they cannot be seen at all; and this is the very position in which the worm naturally lies.

It might therefore be suggested that the present species is merely a younger stage of *S. contortus*, but the circumstance that all the specimens examined were sexually mature tells strongly against such a supposition. Their habitat again is different, and no specimens of intermediate size could be discovered, either in the stomach or intestine.

The present species too wants the peculiar flap guarding the vulva, so characteristic of *S. contortus*.

Another, and I think conclusive, point is that the ova of the smaller species are considerably larger than those of *S. contortus* and also differ somewhat in shape, those of *S. colubriformis* having an elongated elliptical outline, with almost symmetrical poles, while the ova of *S. contortus*, though about the same width, are stouter and ovate, one pole being distinctly blunter than the other.

The size of nematode ova is very constant for the same species, and seems constant through all adult stages of the same worm, so that it forms an excellent specific character. This is very noticeable in the cases of *Dochmius duodenalis*, and *Sclerostomum tetracanthum*. In dimensions and appearance the free, or rhabditis, stages of these species, which I have recently described, are about

[1] *Loc. cit.*

as dissimilar from their entozoic stages as any two nematode species can well be. In each case, however, the ova, whether produced by entozoic, or free-stage worms, are microscopically identical.

I think, therefore, that there can be no doubt that *S. colubriformis* will be found to be a good species; and I have little doubt that it will be ultimately found to have a tolerably wide distribution, as I believe that it is entirely owing to its minute size that it has hitherto escaped recognition.

Although it certainly attaches itself by penetrating the intestinal mucous membrane, it may be doubted if its presence can have any great pathological significance, the small size of, and absence of, armature to the mouth being against the supposition that it has any leech-like propensities, though, at the same time, its dark colour would somewhat countenance such a view. The possibility of it working much harm seems to me to depend entirely on this point, as, if it be a blood-sucking species, very large numbers might quite compensate for its small size, and rapidly produce a destructive anæmia.

In the probable absence, however, of any such habit, the most it can be credited with is an aggravation of the dyspeptic symptoms brought about by the presence of other and more formidable species.

Before quitting our consideration of this worm, I may as well note the very peculiar structure of the female generative ducts. The vulva opens into the middle of a sort of cylindrical sac, which extends for a short distance forward and backward from the vaginal opening. The peculiar point is that the connection between this vagina and the uterine canals is effected by means of a thick, chitinous, valvular apparatus, which closely resembles the œsophageal bulb of certain nematodes, and, on high power examination, is seen to be of a most complicated structure, the chitinous lining of the vagina projecting up into the end of the lax uterine canal, and having a deeply sinuate margin. Surrounding this structure is a very thick muscular ring, which gives the bulb-like outline to the whole apparatus. An exactly similar structure is faintly outlined in Curtice's figure of *S. ventricosus*, though he makes no special mention of it in his text; and something similar is also to be made out in *S. contortus*, though the bulb is proportionally much smaller and weaker, being scarcely more than a thickening of the muscular coat in this situation.

Trichosomum verrucosum, sp. n.

This species, which also appears to be hitherto undescribed, was found in the stomach of a sheep at Shillong, a few being found in each division, except in the reticulum. It seemed then so improbable that so comparatively large and obvious a species should be new that I only collected a few specimens for identification, and I now find that, without exception, these are females. The male is probably much smaller, and so escaped observation.

Owing to the want of male specimens the determination of its generic

position is uncertain. It is even possibly a strongyle, the ova possessing the broad transparent external zone so characteristic of most members of that family; but, on the whole, I prefer to refer it provisionally to the genus *Trichosomum*, more specially as I found attached to one of my specimens a portion of the male generative organ; and this had a curiously echinate sheath, such as is characteristic of many members of that genus.

Description.—Female, about 9 c. m. long ($3\frac{1}{2}$ inches). Somewhat tapered alike at head and tail; but elsewhere uniformly about 0·5 mm. in thickness. The mouth is unarmed, and surrounded by six blunt papillæ. The œsophagus is soft and thin-walled. The skin of the head, and first half inch of the body is thickly beset with irregularly shaped, flat verrucosities, which, however, involve only the cuticular layer.

The female generative opening is situated about 2 mm. in front of the caudal extremity; the otherwise symmetrical uterus on one side making a caudal loop below it, about half-way to the anus, which is situated immediately in front of the caudal extremity, which ends in a curious, finger-shaped process, bent towards the ventral aspect. The uteri are so large that the mature worm seems little else than an elongated sac of ova. The ova (intra-uterine) measure 0·05 mm. in length by 0·027 mm. in width, and are regularly oval in outline with a broad transparent zone and thin external envelope.

The most advanced specimens contained a pear-shaped embryo bent on itself.

Note on **Steongylus ventricosus,** Rud.

While on the subject of ovine parasites, it may be well to note that it is difficult to reconcile the original description of this species with the description and figure of the species which Dr. Curtice[1] identifies by this name. Rudolphi's species was found in *Cervus elaphus*, L. and belongs to Diesing's division of the genus, in which the head is bialate, and the bursa of the male multilobular, both of which characters, to begin with, are conspicuous by their absence in Dr. Curtice's species, the exquisite figure of which is obviously too minutely drawn to admit of any doubt as to its accuracy.

Briefly the differences between the two species may be formulated as below:—

***S. ventricosas,* Rud.**	***Dr. Curtice's species from American sheep.***
Head attenuate with two thin alæ.	Head cylindrically inflated, with no alæ.
Body capillary, about a third from its commencement very thickly ventricose; vulva near the ventricosity.	Body "comparatively stout;" vulva about two-ninths to one-third of the entire length of the female from the tail.
Bursa of the male multilobate, radiate.	Bursa conical and bilobed, the ventral membrane being narrow the dorsal wide.
Length, 6-8″ (13-19 mm.)	Length: male, 6 mm., female, 13 mm.

It will thus be seen that, beyond a superficial resemblance, the only common

[1] *Loc. cit.*, p. 149.

character is the marked ventricosity of the neighbourhood of the vulva, which, however, is differently placed in its relation to the length of the body.

It is obvious then that Dr. Curtice's species is distinct from *S. ventricosus*, Rud. Might I suggest that it should be named *S. Curticii?*

It is obvious that this species is very closely allied to that I have just described as *S. colubriformis.* At first I thought that they might be identical, but the absence of alæ and the cylindrically inflated head, it seems to me, should be sufficient to distinguish them. Moreover, the male bursæ, though very much alike, differ in certain particulars, and I have not been able to find any trace of the peculiar dotted appearance of the skin, which is prominently noticed alike in his description and figure. Further, I have never met with a single female which, by any straining of terms, could be said to be ventricose. At the same time I do not consider the question can be considered as quite settled until actual specimens are compared.

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SANAWAR:
The 26th November 1891.

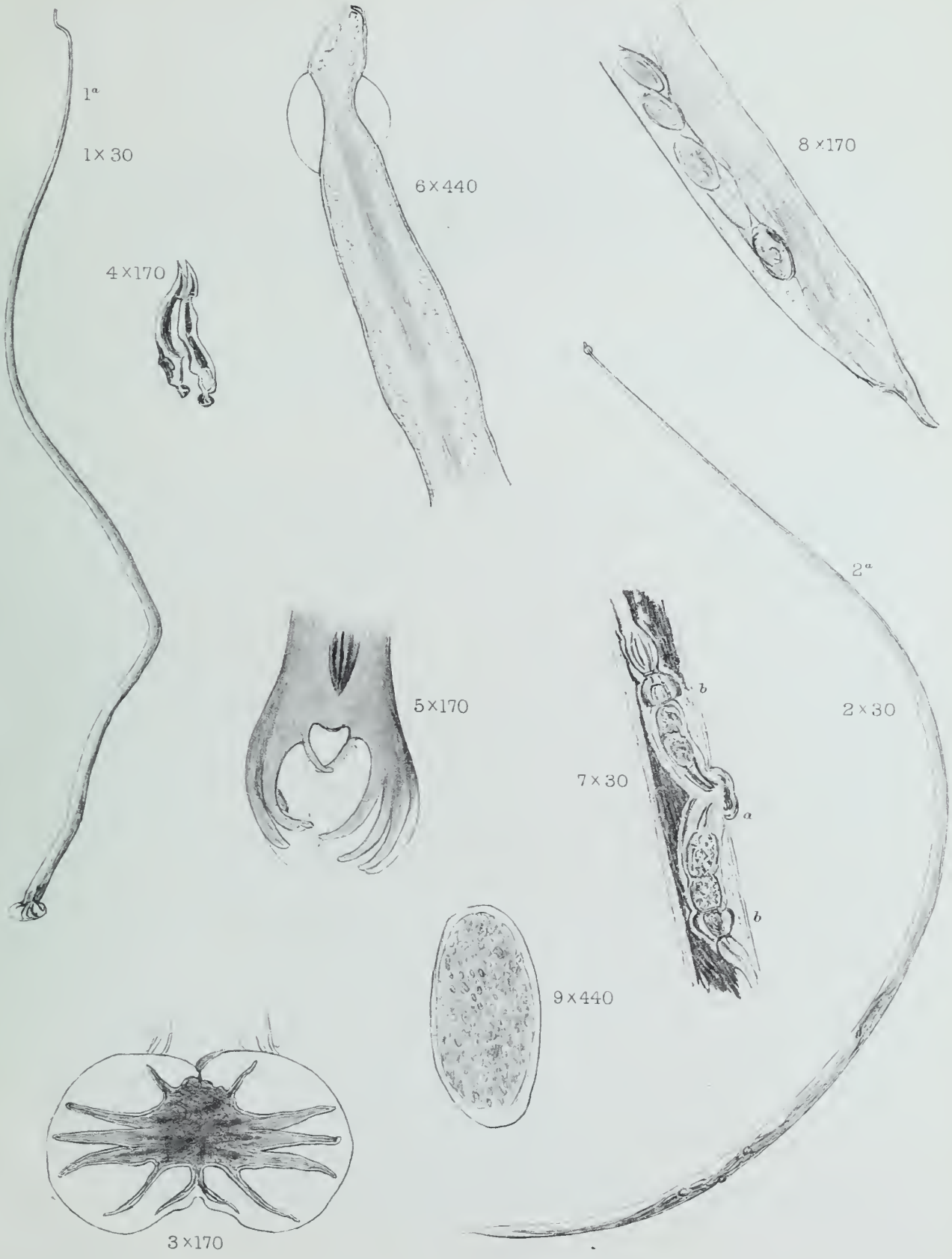
Explanation of Plate

Strongylus colubriformis, sp. n.

FIG. 1. Male × 30 diameters.
,, 1*a*. ,, natural size.
,, 2. Female × 30 diameters.
,, 2*a*. ,, natural size.
,, 3. Male bursa spread, × 170 diameters.
,, 4. ,, copulatory spicula × 170 diameters.
,, 5. ,, bursa viewed somewhat obliquely, from the ventral aspect × 17 diameters.
,, 6. Anterior extremity of female × 440 diameters.
,, 7. Vulvar portion of body of female × 130 diameters—

a—vulva.
bb—valvular apparatus, guarding the mouths of the uteri.
The darkly shaded portion represents the intestine.

,, 8. Caudal end of female × 170 diameters.
,, 9. An ovum (from uterine cavity) × 440 diameters.



Reg No 698 San., I.—Mar. 92.—301.

Litho, S I. O., Calcutta.

A Contribution on the Life History of the male *Filaria medinensis* founded on the Examination of specimens removed from the abdominal cavity of man.

BY

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THE specimens of which the accompanying sketches are fairly faithful representations were removed from the sub-peritoneal tissue of "subjects" undergoing dissection in the Anatomical Department of this College. Figures 1, 2 and 3 represent the calcified remains of specimens of *Filaria medinensis* in various stages of development. These came from one "Subject," and were found in the neighbourhood of the R. Ext. Iliac Vein. The largest was lowest down, the smaller ones being near the R. Sacro Iliac Art. The length of Figure 1 I compute to be about 266 mm. and its diameter 1·8 mm. The smallest specimen, Fig. 3, did not measure, previous to undergoing calcification, more than 30 mm., and its diameter is 0·5 mm. It may have been on its migration from the alimentary canal some time, so that its size on escaping from the intestine was probably very much less than the foregoing measurement. The cellular tissue around was thickened as if it had been the seat of old inflammation. The calcified remains are each surrounded by a sort of boundary membrane, which evidently, on the subsidence of the inflammation, closed them severally off from the general economy. Why the worms died it is impossible to say. It is probable that, if the host suffered from continued fever of a high temperature, their vitality may have been interfered with and their destruction ensured. Enlarged spleen was present, thus showing that the host had in his time been a malarial subject. The worms having died, the deposition of lime salts in their tissues is easily understood. This calcification has left beautiful casts of the worms, demonstrating well the rounded shape and the calibre of the body. Neither head nor tail can be made out. I consider there is no doubt that the specimens represent immature guinea-worms. My reasons for considering them so are—

(1) Shape of body proves them round worms, Nematoda;

(2) The calibre, 1·8 mm., and length, 266 mm. (about), agrees with that of *Filaria m.*;

(3) The *Eustrongylus* Gigas has a similar length, but its calibre is much greater, and, moreover, it is very rare in man : the kidneys also of the "host" were not diseased;

(4) The finding of uncalcified specimens (Figures 4 and 5) of guinea-worms in another "subject" a few weeks later confirmed the suspicions I already had of the affinity of the calcified parasites.

Figures 4 and 5 are drawings of Nematoda taken from near the attached portion of the mesentery from out of the sub-peritoneal tissue—in the vicinity of the Ileo-cœcal valve. I regret the specimens were injured on removal. The remains of the largest—Figure 4—I have joined together, and so obtained a sketch of a worm presenting all the characteristics of *Filaria medinensis*. On examining two (there is only a drawing of one of these—the second unfortunately was placed in spirit and hence spoilt—that of which the drawing is made was preserved in glycerine) I was struck by seeing something growing from the side of each of them. This "something" I found to be a round worm with the characters of that to which it was attached. On drawing upon it with a forceps I found, to my astonishment, that it was possible to pull it out of the body of the larger worm from a small opening near its middle (thus showing that it was not a case of a worm with a bifid body). I did not completely pull it out, and only withdrew it about 1 cm. I was then of the opinion that I had found a male and female round worm in the process of copulation and at the same time that I had discovered the long sought for male Dracunculus! The female (Figure 5 *b*) was 148 mm. long and 1·2 mm. in diameter: the posterior extremity of the body, however, was broken off. The male (Figure 5*a*) was much smaller and somewhat shrivelled, though showing in every way the peculiarities of a separate individual Nematode. Want of leisure compelled me to place my specimens aside. This I did, preserving the fragments of one male and female (Fig. 5) in glycerine and of another male and female in spirit. A single large female (Figure 4) I placed in glycerine. This was in March last. Furlough to Europe has prevented me prosecuting the subject further at an earlier date. The specimens have suffered somewhat, but even now the male and female in copulation (Fig. 5) can be well seen, though the male has been considerably injured. No embryos or ova can be made out. It cannot be expected, however, that embryos should be found, as the ova would not be fertilised, or rather the embryos would not be freed from the ova till some time after fertilization, which was just in progress. The head with the mouth can be seen. There seems to be a dilatation behind the mouth (- pharynx). The tubercles on the head are shown in Fig. 6, which figure also illustrates the character of the muscular pharynx. The mucronate tail is well marked in Fig. 5. Under a low power the transversely striated cuticle covering a muscular body is apparent. The tail of the male is in the body of the

female, and hence cannot be seen ; otherwise, the characters of his body are similar to those of hers.

I shall now briefly trace the life history of the guinea-worm. Beginning with the female, heavy with young, drawn from the body of the human host by the itinerant barber, who ignorantly casts the extracted worm on the ground, where the decomposing body gives issue to thousands of living embryos. These, gaining water by means of the wind or rain, migrate (according to Fedschenko) into the body of a cyclops, upon which they become parasitic, becoming coiled up within its limbs ("as many as 6 or even 12 of the parasites being occasionally found within the body of a single crustacean host"), and reaching there full larval growth. A human being drinks the water containing the infected cyclops. The juices of his intestine, digesting the Entomostracan, liberate the matured larvæ —*male and female.* Rapid growth takes place in these. The males attach themselves to the females, both leaving the intestine together for the safer retreats of the retro-peritoneal tissues. The exodus probably occurs where the mesentery is attached to the bowel—the planes of peritoneum forming the mesentery directing their course in the sub-peritoneal connective tissue to the back of the abdomen in the neighbourhood of the lumbo-sacral articulation, where, in a nidus, well-nourished by the abundant blood supply, the female parasite can remain at ease and grow at leisure, unaffected by the contractions of muscles, and undisturbed by surface chills. She increases in size from the growth of her uterine organs. The poor male, gradually diminishing, comes to appear only as an appendage to his mate—having completed the task allotted to him—that of fertilising her.

The time the female remains in these internal regions will vary according to the state of development of her contained embryos. On maturation the wandering again takes place—may be down on the Psoas under Poupart's Ligament, being guided by the muscular planes to "point" on under surface of the deep fascia in some region of the thigh or leg, just as a Psoas abscess may "point" either in the inside of thigh or as low as side of ankle! A more posterior exit from the abdominal cavity—that by the Gt. Sciatic Notch in company with the Sciatic Ns. and Vs. to the buttock—would lead the wanderer down the back of thigh to calf by way of the Popliteal space. Having arrived under the deep fascia, it would act as a foreign body. Interfering with the proper contraction of the muscles, the irritation of its presence would cause an abscess by which the imprisoned worm would be liberated. The male dies in the sub-peritoneal tissues, the female finishes her course on the surface of the body!

In the life history and morphology of the *Filaria medinensis* certain points are up to this doubtful or unknown. As (1) Where does the impregnation of the female occur? (2.) What becomes of the male? (3) How is it that no sexual orifice has been discovered on the body of the female?

Claus (Sedgwick's Translation, 1889) says, "Whether they first escape" (*i.e.*, from the body of the cyclops) "and copulate in a free state is not known." Cobbold (1879) says, "It is probable that sexual maturity is next acquired within the human stomach, copulation following." Granting that the specimens found by me are male and female guinea-worms, Cobbold's view would be correct. This learned Helminthologist a little further on says, "The females migrate to the situations in which they are found beneath the skin of the human bearer, *whilst the male perishes and passes out with the fæces.*" The italics are mine. This, however, is not so. The female pierces the wall of the intestine *accompanied by the male*, which remains attached to her body till impregnation be fully accomplished. Then dying, his body, gradually shrivelling up, would not be discovered when the female had reached her host's skin. Copulation in this instance is a slow process. The male is, as it were, a parasite on his paramour, and being attached to her genital aperture (as in parallel cases amongst the lower Crustacea) gradually wastes away in the delights of love! This explains why the male has not been discovered with the adult female on her arrival at the body surface. Although no sexual orifice has been found on the adult, yet such an opening may be seen on the young form after it leaves the intestine, as, at that time, its uterine organs are not distended with crowds of microscopic embryos, causing almost an obliteration of the perivisceral cavity. The Vulva is small in comparison to the size of the worm, and is only used for impregnation, *not* parturition: therefore, as development proceeds—there being no necessity for its presence—it would degenerate and diminish as the body swelled from the contained embryos. But if the parasite be discovered in the neighbourhood of the mesentery—that is, soon after its start on its journey—and a second parasite be found attached to the side of the larger, out of an opening on which it can be withdrawn, are we not justified in saying that the orifice in the larger worm is a genital aperture, and that the attached worm, which was withdrawn out of this aperture, is the male parasite?

The reason why the male form has not before been met with, I think, is probably due to the fact that it is only likely to be found on a *dissection* of an *infected* subject, and not merely on the *post-mortem* examination of a body containing the parasites in the regions in which I discovered them. The male wastes and becomes small, having impregnated the female. He dies in the abdomen, and his attached remains in all likelihood would be lost owing to the friction of the tissues on the body of the female during her progress down the extremity.

The discovery of comparatively large females, and of males and females together, in the abdomen practically proves that infection with this parasite takes place by the alimentary canal, and finally disposes of the old idea that the parasite could gain entrance by the skin of the extremities or back. It passes *from within out*, NOT from without in.

In conclusion, I may suggest the possibility and probability of cases of Psoas and Iliac abscess and obscure pains in the post-abdominal and pelvic regions being at times due to the irritation of this parasite. The neighbourhood of the Pelvis where the calcified specimens were found showed, as I have previously stated, signs of old inflammation, and the 'remains' were walled off from the system by the usual protective membrane.

Explanation of Plates.

Figures 1, 2, 3. Calcified remains of *Filaria medinensis*, corresponding to three separate worms, ♀ probably.

The "cast" in figure 1 is an excellent one: the round body is well shown; neither head nor tail can be made out. This is the most mature of the specimens, and was found nearest of the three to Poupart's Ligament in the neighbourhood of the External Iliac vein of right side. It is encapsuled by a thin membrane evidently derived from the surrounding tissues and inflammatory in nature.

Figures 2 and 3 are smaller, and represent specimens of a very much less mature age. The diameter of the body of figure 3 is not one-fourth that of the body of figure 1. These calcifications remind one of the convoluted abodes of some of the Tubicolæ seen on the outside of shells on the sea-shore.

Figure 4.—Filaria medinensis ♀. Life-size drawing of worm. The three pieces of which it consisted have been placed in position and the sketch made from them. Length about 284 mm. Diameter 1 mm. Papillæ on head not seen. Mucronate tail well shown.

Figure 5.—Filaria medinensis—male and female in copulation. Represented twice the actual size.

The male (*a*) has been somewhat injured about the free end, which is the head; the brownish striæ down from head correspond to the injured "pharynx." This is better shown in the case of the female (*b*), on the head (*d*) of which the brownish marking with a dilatation is seen. The other extremity (*c*) of the female is broken off. The genital opening (*e*) of the female is shown, though it is perhaps represented too definitely. It is the tail end of the male which is within the body of the female. This specimen when found in March last was in excellent preservation. At that time I partially withdrew the male, but did not completely do so, not wishing to spoil the position of the worms. Now, although everything is quite plain, the male is somewhat dilapidated.

Figures 4 and 5—Were removed from near the sacral promontory. It will be noted that in the two "subjects" from which all the specimens—calcified and uncalcified—were removed the seat of the parasites was either in the sub-

peritoneal tissue of the attachment of the mesentery to the post-abdominal wall, or in the same tissue a little further down—the smallest specimen being highest up and nearest to the intestine.

Figure 6.—Drawing of head of female (shown in Figure 5) by means of the Camera Lucida × 25. The tubercles on head are well shown (*a*). The mouth and dilatation behind it (pharynx) will be observed—

a = tubercles,
b = cuticle,
c = muscle fibre,
d = internal cylinder extending from mouth,

It will be observed that the alimentary canal is easily seen in the less mature specimens (Figures 5 and 6), whilst in the older and more developed worm the alimentary canal is not apparent (Figure 4).

Figure 7.—Drawing of mucronate tail of worm, shown in Figure 4, by means of Camera Lucida × 25—

a = transversely striated cuticle,
b = muscular fibres.

For the sketches of Figures 6 and 7 I am indebted to the kindness of Dr. Murray, Professor of Pathology in this College.

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Surgeon, Bengal Medical Service.

The 15th December 1891.

G. I. C. P. O.—No. 16 S. C.—25-4-92.—300.

Fig. 1

Fig. 2

Fig. 3

Fig. 4

Fig. 5

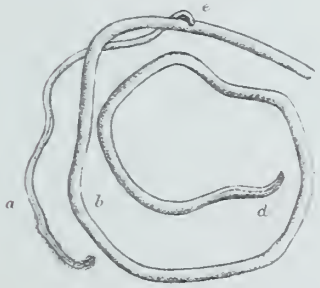
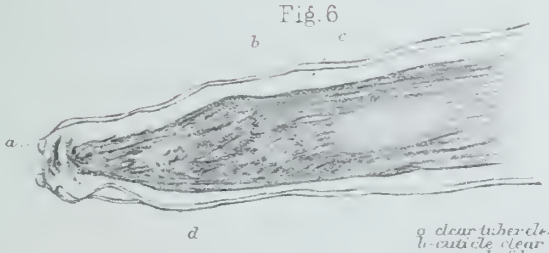
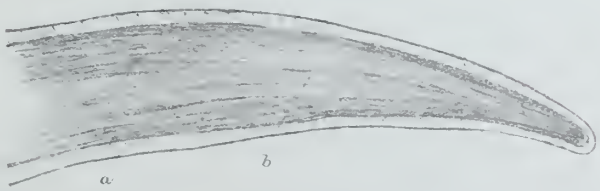


Fig. 6



a clear tubercles
b-cuticle clear
c-muscle fibre
d-dark internal cylinder

Fig. 7



a-cuticle
b-muscle fibre

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Litho. S. I. O. Calcutta

SCIENTIFIC MEMOIRS

BY

MEDICAL OFFICERS OF THE ARMY OF INDIA.

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